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भारतीय मानक

ज्यामितीय अभिविन्यास तथा गति की दिशाएँ

Indian Standard

GEOMETRICAL ORIENTATION AND DIRECTIONS OF MOVEMENTS

ICS 13.180

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

September 2002

Price Group 11

Machine Tools Sectional Committee, BP 03

NATIONAL FOREWORD

This Indian Standard which is identical with ISO 1503 : 1977 'Geometrical orientation and directions of movements' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of the Machine Tools Sectional Committee and approval of the Basic and Production Engineering Division Council.

The text of the ISO Standard has been approved as suitable for publication as Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

> Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

There is no corresponding Indian Standard to IEC Publication No. 447 and ISO 1151-1 at present.

The following editorial changes have been incorporated in Indian Standard that does not alter the technical contents of ISO Standard while adopting under dual numbering:

a) Reference to Note No. 3 of para (a) of Clause **4** (Page 9) — Footnote 3 has been deleted.
b) Viewing system indicated under Fig. 14, Page 12 has been in line with given figure.
c) Reference to Note No. 1 in first para of Clause **7.1**, Page 20 and footnote has been deleted.
d) VSI given in text under Fig. 40, Page 24 has been corrected as VSE.
e) Foreword has been align alebrated as 'away from the operator' and backward as towards the operator against Fig. 41 to 44 of Annex A, Page 31.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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IS 15257 : 2002
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Indian Standard

GEOMETRICAL ORIENTATION AND DIRECTIONS OF MOVEMENTS

0 INTRODUCTION

The geometrical orientation of technical objects, as well as the unambiguous definition of the direction of movement of objects or their parts, is often of decisive importance : an unclear or wrong direction could, for example, seriously hinder the task of rescue teams in a burning building; the operation of a valve or steering lever in the wrong direction could, in dangerous circumstances, lead to a disaster.

Hence, the standardization of the directions of technical objects (geometrical orientation), as well as the standardization of directions of movement, is of great importance especially as regards safety.

For the electrotechnical field, IEC Publication No. 54, *Recommendations for standard direction of motion of operating devices and for indicating lamps for circuit-breakers*, was published in 1936 (Part 1 of this publication is now replaced by IEC Publication No. 447 – first edition, 1974). In the field of mechanical engineering, a whole series of International Standards exists for special fields of application.

On the other hand, many cases may be quoted where corresponding standards are lacking. It also happens that in the standards of various technical fields or in the various national standards the directions of movement have been specified in differing and conflicting ways.

This International Standard should help to solve problems in relation to geometrical orientation, directions of movement and steering elements, and to unify the relevant stipulations worldwide and in all disciplines.

Because alterations of existing practice and standards in relation to steering elements often result in danger, it is strongly recommended that note should be taken of the rules given in 10.4 of this International Standard.

1 SCOPE AND FIELD OF APPLICATION

This International Standard

- establishes and defines directional terms in stationary circumstances (geometrical orientation);
- defines directions of movement and gives rules for establishing them;
- gives rules for the co-ordination of directions of movements of control elements to the intentional changes in technical objects.

It is a fundamental standard to be used when drawing up other standards where the geometrical orientation or the direction of movement plays a role.

2 CONSIDERED OBJECT

Object whose geometrical orientation or whose movements are to be defined or established.

2.1 Geometrical orientation of the considered object

For a geometrical orientation of the considered object, the determination of a centre point as well as the three axes of the considered object described in 2.3 or the three reference planes described in 2.4 are required.

The considered object may already be by nature geometrically orientated or receive a geometric orientation by convention. The following distinctions are made depending on the degree of geometrical orientation :

2.1.1 Fully orientated object geometrically speaking

Object which by nature possesses an individual complete directional system with longitudinal transverse and normal axis (see 2.3.1 to 2.3.3).

In these circumstances the directions right and left, above and below, in front and behind, are firmly unambiguous. With them the three reference axes are also established (see 2.3).

Examples :

- ship (see figure 1);
- aeroplane, automobile;
- interior of a church;
- interior of a theatre, lecture hall (with unidirectional seating arrangement);
- wind rose on a compass;
- switchboard, instrument panel;
- map (see figure 2);
- cabinet.

2.1.2 Incompletely orientated object geometrically speaking

Object which by nature possesses only an incomplete directional system, not all of its three axes being determined. In the case of most such objects, only one or two directions are fixed, whilst the other one or two directions are undetermined and must be specified conventionally if necessary.

Examples :

a) Objects in which position and direction of the longitudinal axis X (see 2.3.1) are fixed :

- spear;
- rocket.

b) Objects in which position and direction of the normal axis Z (see 2.3.3) are fixed :

- flag pole;
- factory chimney (see figure 3).

c) Objects in which the **position and direction** of the normal axis Z and the **position** (but not the direction) of the longitudinal axis X and the transverse axis Y are fixed :

- railway wagon;
- container;
- pontoon.

d) Objects in which only the position of the transverse axis Y (see 2.3.2) is fixed :

- roller;
- wheel.

e) Objects in which only the position of one of the three axes X, Y or Z is fixed :

- cylinder;
- pipe (see figure 4);
- cable, wire.

2.1.3 Object not geometrically orientated

Object which possesses by nature no directional system.

Examples :

- ball, balloon;
- cubical block;
- box without inscription on it.

2.2 Centre point

Assumed reference point for the geometrical orientation of the considered object and the determination of movements.

The imaginary centre point need not coincide with the centre of gravity of the considered object.

2.3 Axis of the considered object

One of the three assumed infinite mutually perpendicular straight lines through the centre of the considered object.

The three axes are designated X, Y and Z.

NOTE — These symbols have been adapted to the common practice in aeronautic (see ISO 1151/I, *Terms and symbols for flight dynamics — Part I : Aircraft motion relative to the air*).

The determination of the positive direction of the three axes has not yet been adhered to, because, up to now, it has not been possible to find a solution which unifies the various stipulations on the different special branches : for example mathematics, aviation, machine tools, electrical engineering, etc. But it is not absolutely necessary for the three-dimensional orientation and the determination of the directions of movement.

2.3.1 Longitudinal axis X

Infinite straight line through the centre point of the considered object, running from back (behind) to front (see figures 5 and 6).

2.3.2 Transverse axis Y

Infinite straight line through the centre point of the considered object, running from left to right (see figures 5 and 7).

2.3.3 Normal axis Z

Infinite straight line through the centre point of the considered object, running perpendicularly to the longitudinal axis X and the transverse axis Y and from top to bottom (see figures 6 and 7).

2.4 Reference plane

One of three imaginary mutually perpendicular planes through the centre point of the considered object which, in each case, contains two axes of the same object.

The reference planes are needed for the geometrical orientation of the considered object and for the definition of linear movements. They are aligned according to the considered object and not according to the earth's surface.

Since the considered object can occupy any position relative to the earth's surface, the reference planes can also have any position relative to the earth's surface.

It is only with objects whose directional system is aligned according to the earth's surface or the earth's horizon that the basic plane is a horizontal plane, while the longitudinal and transverse planes are vertical planes.

2.4.1 Basic plane P_{xy}

Reference plane through the centre point of the considered object containing the longitudinal axis X and the transverse axis Y (see figure 5).

2.4.2 Longitudinal plane P_{xz}

Reference plane through the centre point of the considered object containing the longitudinal axis X and the normal axis Z (see figure 6).

2.4.3 Transverse plane P_{yz}

Reference plane through the centre point of the considered object containing the transverse axis Y and the normal axis Z (see figure 7).

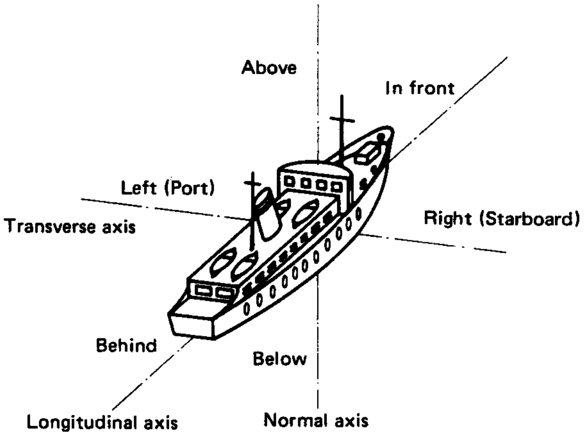


FIGURE 1 – **Ship as an example of a fully orientated object geometrically speaking**

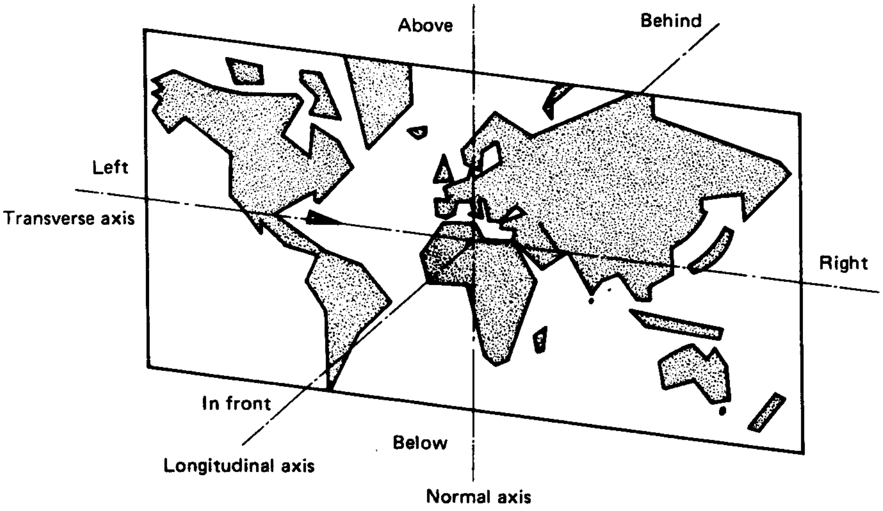


FIGURE 2 – **Map as an example of a fully orientated object geometrically speaking**

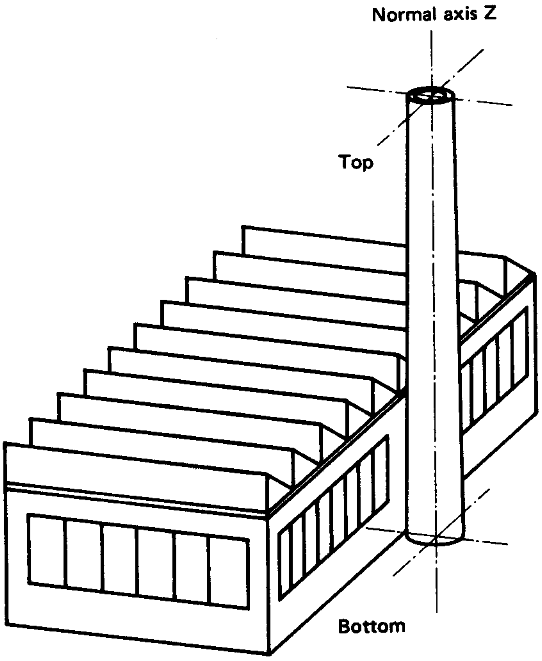


FIGURE 3 — **Factory chimney shown as example of incompletely orientated object, geometrically speaking**

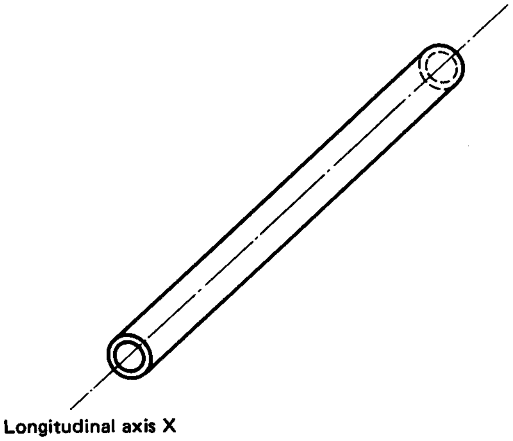


FIGURE 4 — **Pipe shown as example of incompletely orientated object, geometrically speaking**

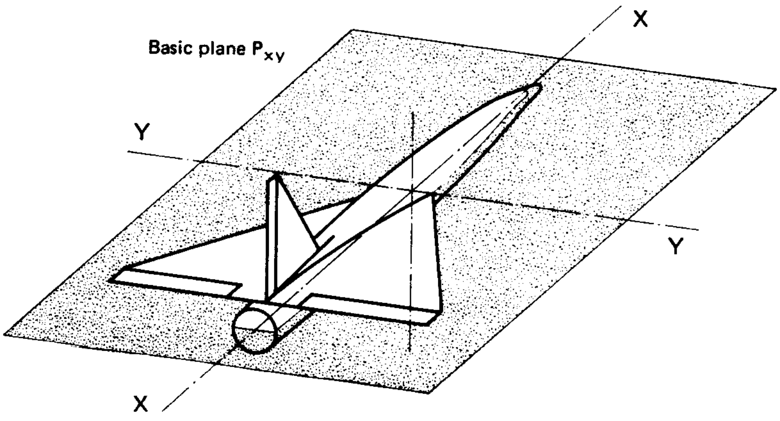
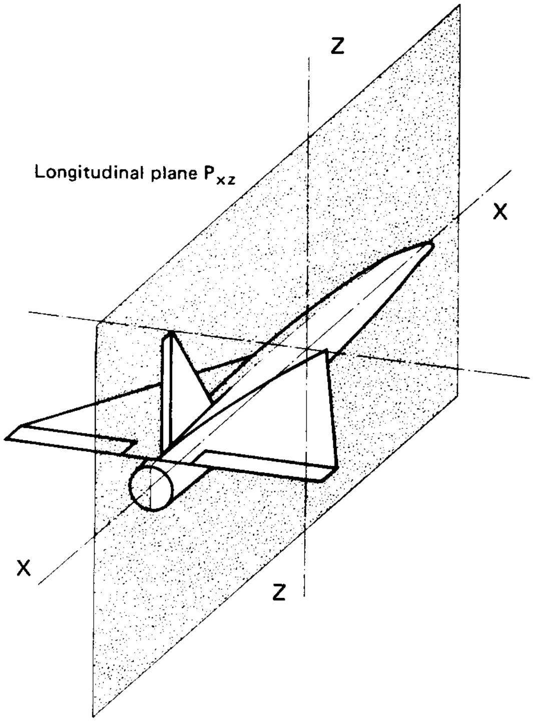


FIGURE 5 – **Basic plane P_{xy}; longitudinal axis X; transverse axis Y**



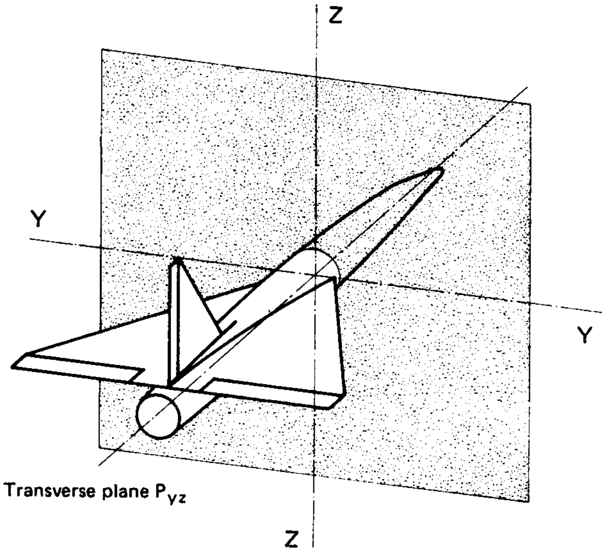


FIGURE 6 – **Longitudinal plane P_{xz}; longitudinal axis X; normal axis Z**

FIGURE 7 – **Transverse plane P_{yz}; transverse axis Y; normal axis Z**

3 OBSERVER

Real or imaginary person whose location, posture and viewing direction are the basis for all directional data.

The observer may be a person who views the considered object from without or within, in order to determine the direction of parts, points or movements of the same; he may, however, also be a person who actively controls the movements of the considered object or the movements of parts of the same. In this case the observer is the operator.

The correct choice of the imaginary location, posture of the body and viewing direction of the observer is of decisive importance for the three-dimensional orientation of objects and for the determination of directions of movements.

3.1 Location of the observer

Assumed place at which the observer is located for the determination of directions and movements.

For simpler and more accurate determination of directions, the location of the observer is taken to be on one of the three axes. This imaginary location is generally not identical with the real location of the observer and coincides with it only in exceptional cases.

NOTE — In the following illustrations the imaginary observer is shown in black and the actual observer in white.

It is important to specify whether the location of the observer is taken to be on the axis outside or inside the considered object.

Frequently the location of the observer is considered to be inside the considered object, although the object itself is so small that there would not be room for a person inside.

3.2 Posture of the observer

Assumed posture of the observer for the determination of directions.

For three-dimensional determination (geometrical orientation) of objects and determination of directions of movements, in most cases the upright posture (standing or sitting) or the posture bent forward is assumed irrespective of the true position of the observer. The body axis of the observer is in this hypothesis parallel to one of the axes and lies in a reference plane containing this axis.

Example :

— body axis of the observer parallel to the normal axis Z in the longitudinal plane P_{xz}.

3.3 Viewing direction of the observer

Assumed direction in which the observer looks, when determining the directions.

For simpler and more accurate determination of directions it is assumed that irrespective of the observer's actual viewing direction he is looking in the direction of one of the three axes of the considered object. It must not be assumed that the viewing direction is always perpendicular to the observer's body axis.

Examples :

- crane operator (see figure 8);
- person looking at a clock tower (see figure 9);
- person looking at a book (see figure 10);
- worker on a remote-controlled machine tool;
- passenger in a motor vehicle who looks sideways out of the window;
- passengers sitting opposite in a train (see figure 11).

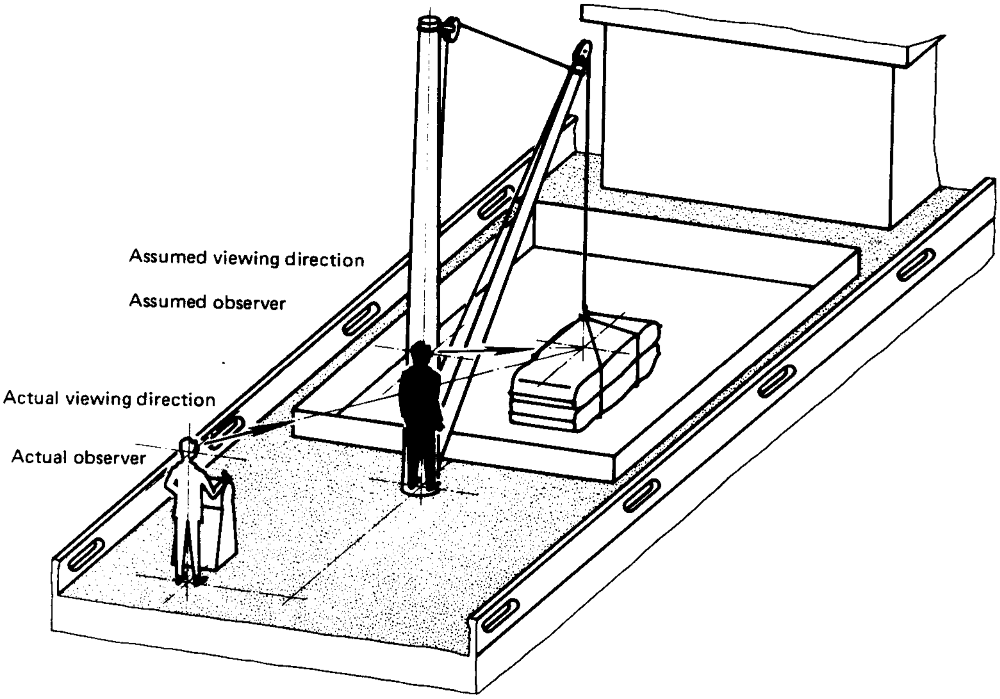


FIGURE 8 – **Assumed location, posture and viewing direction of the observer (= theoretical operator) of a crane (black figure) and actual location, posture and viewing direction of the operator (white figure)**

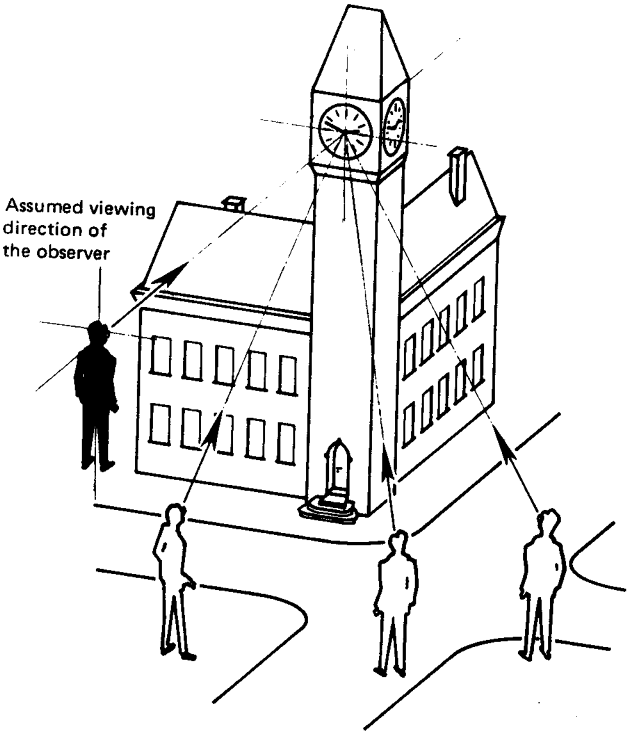

Assumed viewing direction of the observer
Actual viewing directions of the observers

FIGURE 9 – **Assumed location, posture and viewing direction of the observer (black figure) and different actual observers and their location, posture and viewing direction (white figures)**

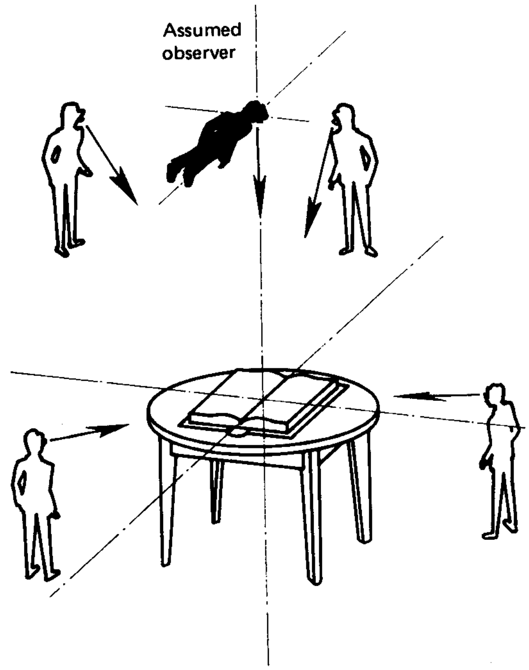


FIGURE 10 – **Assumed location, posture and viewing direction of the observer (black figure) and different actual observers and their location, posture and viewing direction (white figures)**

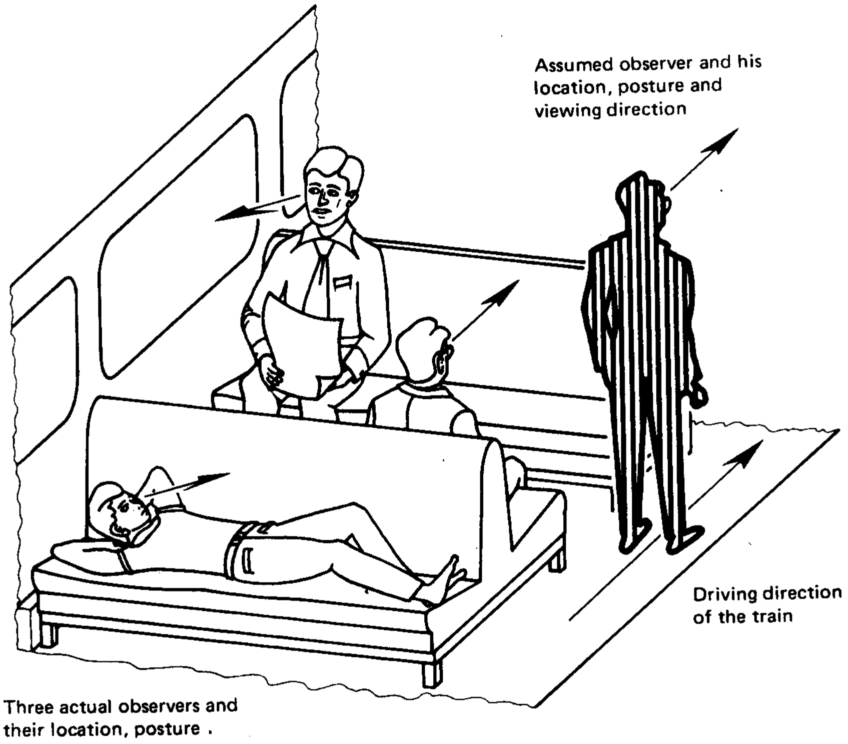


FIGURE 11 – **Assumed observer (black figure) and his location, posture and viewing direction in a railway train, and actual observers in their location, posture and viewing direction (white figures)**

4 VIEWING SYSTEM FOR THE DETERMINATION OF DIRECTIONS

System in which position, posture and viewing direction of the observer are fixed with reference to the three axes of the considered object in order to render possible its geometrical orientation and determination of its directions of movement unambiguously.

There exist two different systems, the external viewing system (VSE)[1] (see 4.1) and the internal viewing system (VSI)[2] (see 4.2). Which of the two systems should be chosen cannot usually be decided arbitrarily but will depend upon the nature of the observed object.

The fact that these two different viewing systems must be considered is frequently the cause of contradictions and misunderstandings. However, it is not possible to abandon one of them without provoking far-reaching changes in existing habits and the modification of many international and national standards. Changes initiated in this way would in all probability not be carried through in practice.

In both viewing systems the following viewing directions are used (see figures 12 and 13) :

a) direction X = viewing direction along the longitudinal axis X forwards for a normally moving object (VSI) or towards the front of the object if normally stationary (VSE);

b) direction Y = viewing direction along the transverse axis Y to the right;

c) direction Z = viewing direction along the normal axis Z downwards.

The direction X, direction Y and direction Z together form a right-hand system of co-ordinates.

4.1 External viewing system (VSE)

Viewing system in which it is assumed that the location of the observer lies outside the considered object (see figure 12).

For the three-dimensional orientation (see 5.1 to 5.3), for the determination of linear movements (see 6.1 to 6.3) and for the determination of rotations about the longitudinal axis X (see 7.1), the assumed place of the observer is in front of the considered object on the longitudinal axis X. His posture is upright while he is looking in the direction of the longitudinal axis X (direction X) at the front of the considered object.

For the determination of rotations about the transverse axis Y (see 7.2), the assumed place of the observer is on the left side of the considered object on the transverse axis Y. His posture is upright while he is looking in the direction of the transverse axis Y (direction Y) at the left side of the considered object.

For the determination of rotations about the normal axis Z (see 7.3), the assumed place of the observer is above the considered object on the normal axis Z. His posture is lying, parallel to the longitudinal axis X, the right side of his body being on the right side of the longitudinal plane P_{xz}. In this posture, he is looking in the direction of the normal axis Z (direction Z) at the top of the considered object.

Generally, the external viewing system is used for objects which are usually regarded from the outside, but rarely for vehicles.

Examples :

- technical drawings, books, maps, magazines;
- pictures, sculptures;
- measuring devices, clocks, switchboards;
- showcases, theatre stages;
- containers, all kinds of wrappings;
- the exterior of buildings;
- landscape units.

4.2 Internal viewing system (VSI)

Viewing system in which the location of the observer is assumed to be inside the considered object (see figure 13).

For the three-dimensional orientation (see 5.1 to 5.3), for the determination of linear movements (see 6.1 to 6.3) and for the determination of rotations about the longitudinal axis X (see 7.1), the assumed place of the observer is in the centre of the observed object. His posture is upright while he is looking in the direction of the longitudinal axis X (direction X) from the centre forwards.

For the determination of rotations about the transverse axis Y (see 7.2), the posture of the observer is upright, while he is looking in the direction of the transverse axis Y (direction Y) from the centre to the right.

---

[1] VSE = abbreviation for Viewing System; External

[2] VSI = abbreviation for Viewing System; Internal

For the determination of rotations about the normal axis Z (see 7.3), the posture of the observer is lying, his head forward while he is looking in the direction of the normal axis Z (direction Z) from the centre downwards.

The internal viewing system will mostly be used for objects which are normally observed from inside.

Examples :

- vehicles in general, such as aeroplanes, ships, automobiles, trains, motorcycles, bicycles;
- cranes and other handling equipment;
- drills or milling cutters in action;
- interior of rooms (church, lecture halls, theatre, factory halls).

It is also used for objects whose movements are remote-controlled from outside, as though the operator were inside the observed object.

Examples :

- remote-controlled vehicles, especially miniature vehicles;
- remote-controlled moving parts, for example in a radioactive room.

4.3 Choice of viewing system

With completely orientated objects, geometrically speaking (see 2.1.1), the choice of viewing system should be determined by the characteristics of the considered object.

In the case of incompletely orientated objects, geometrically speaking, in which generally only one single axis is fixed, the direction of the second and third axes — in some cases also their position — must be established by convention. In determining the direction of the second and third axes, the decision has also been made as to the use of the external viewing system (VSE) or the internal viewing system (VSI).

With geometrically unorientated objects, all three axes must be specified by convention and appropriate choice is made of the viewing system.

It should be noted that adjacent objects or related parts are frequently assigned to different viewing systems. Thus, for example, a motor vehicle is assigned to the internal viewing system (VSI) whereas the instruments on its dashboard are assigned to the external viewing system (VSE).

A balance, measuring device and book lying on a table (see figure 14) are, for example, allocated to an external viewing system (VSE) in the same way as the table itself. The positions of the axes of the balance, the book, the measuring device and the table, however, do not have to align.

It is also often necessary that closely spaced similar objects be observed separately to determine their geometrical orientation and to determine their directions of movement, and to use for each object an individual viewing system.

Example :

- switchboard as in figure 15.

If, in the case of geometrically incompletely orientated objects, and objects which are not orientated geometrically at all, there are two possibilities for the choice of the appropriate viewing system, it is advisable to specify the more significant of the two choices in international or national standards.

Example :

- viewing system for an internal combustion engine as shown in figures 17 and 18.

NOTE — Since in the example shown in figures 17 and 18 only the normal axis Z in position and direction is inherent, the engine is a geometrically incompletely orientated object. Only through the choice of the other axes, which is at the same time the choice of the viewing system, are the directions of the longitudinal axis X and of the transverse axis Y determined.

Comparison of different national standards shows that both solutions, i.e. the external and the internal viewing systems, have been used in different fields (for example, marine engineering and motor vehicle engineering) as well as in different countries.

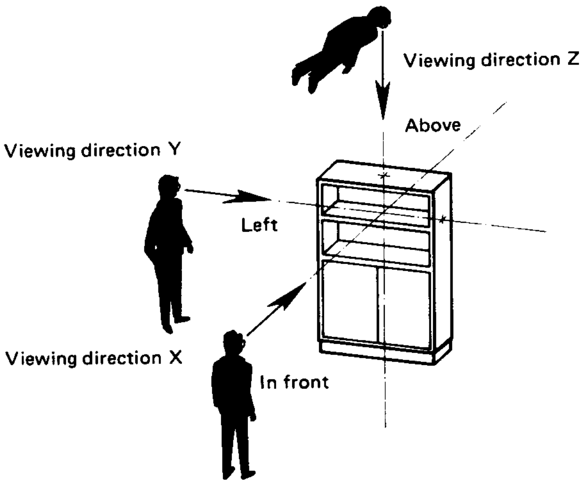


FIGURE 12 – **External viewing system (VSE) for the three-dimensional orientation and the determination of the direction of movements; location, position and viewing direction of the observer**

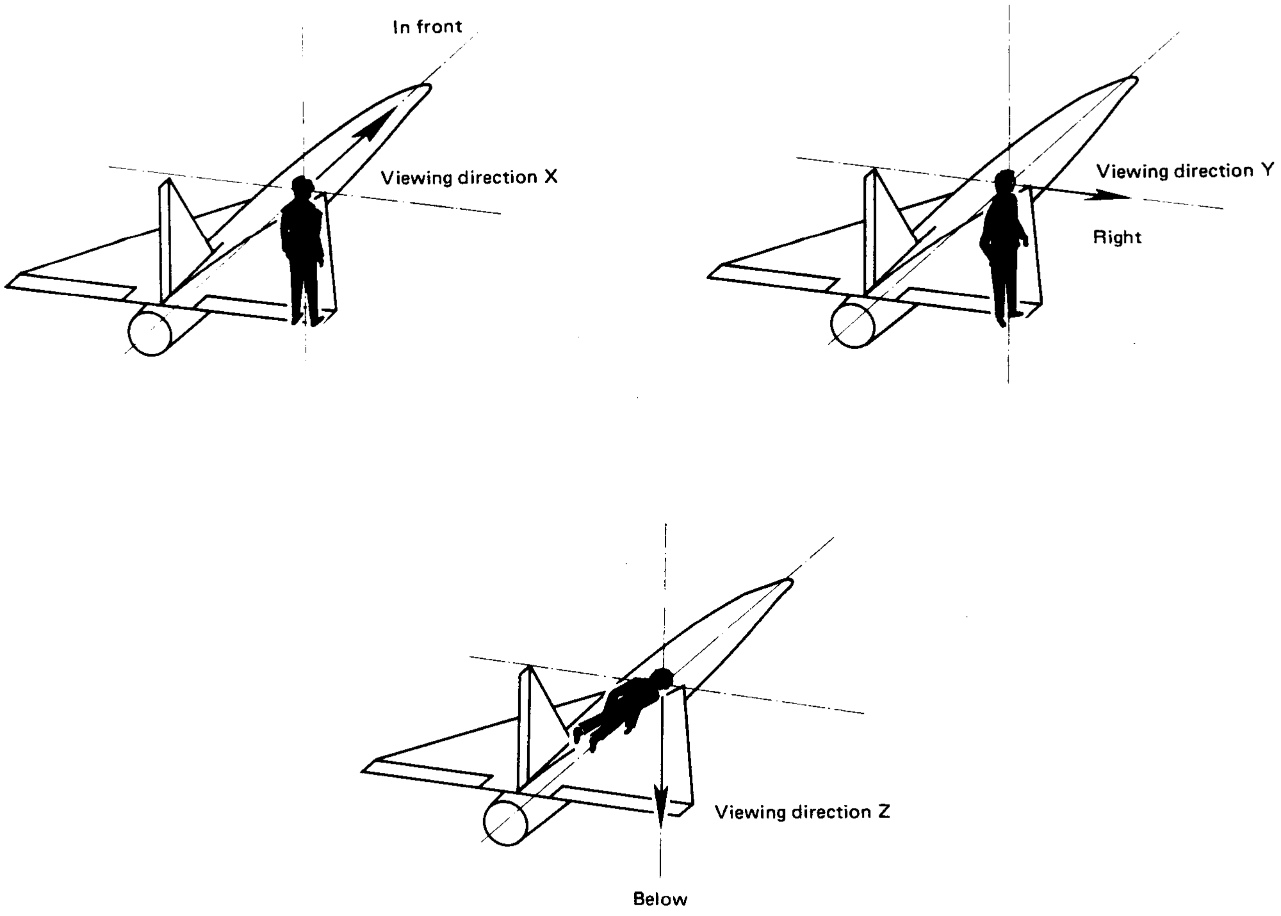


FIGURE 13 – **Internal viewing system (VSI) for the three-dimensional orientation and the determination of the direction of movements; location, position and viewing direction of the observer**

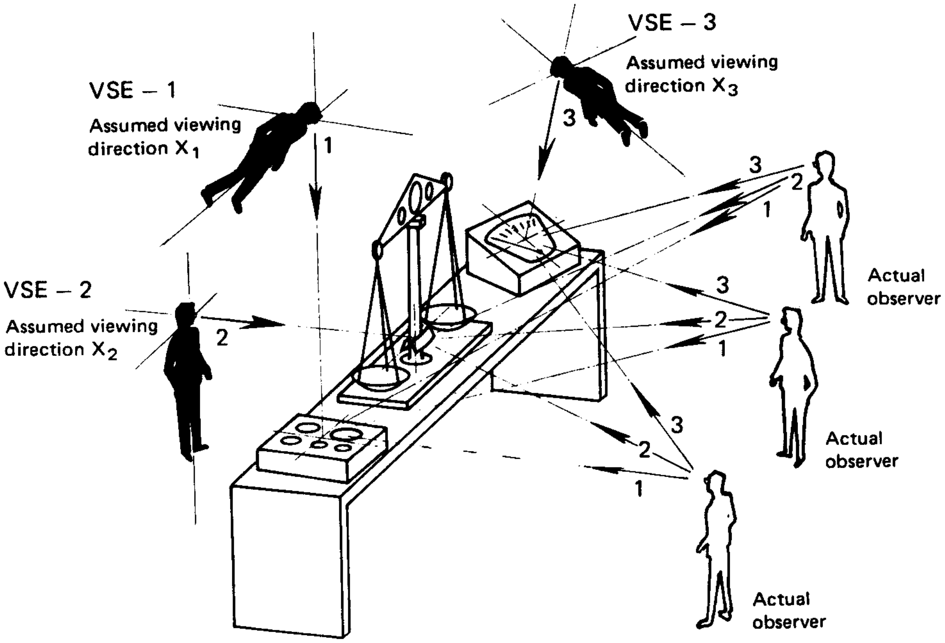

VSE – 3
Assumed viewing direction X_3
VSE – 1
Assumed viewing direction X_1
3
1
3
2
1
VSE – 2
Assumed viewing direction X_2
2
Actual observer
3
2
1
Actual observer
3
2
1
Actual observer

FIGURE 14 – Different viewing systems, shown by the example of a table with balance, measuring instrument and book :

* a) Viewing system VSE – 1 for the book
b) Viewing system VSE – 2 for the balance
c) Viewing system VSE – 3 for the measuring instrument

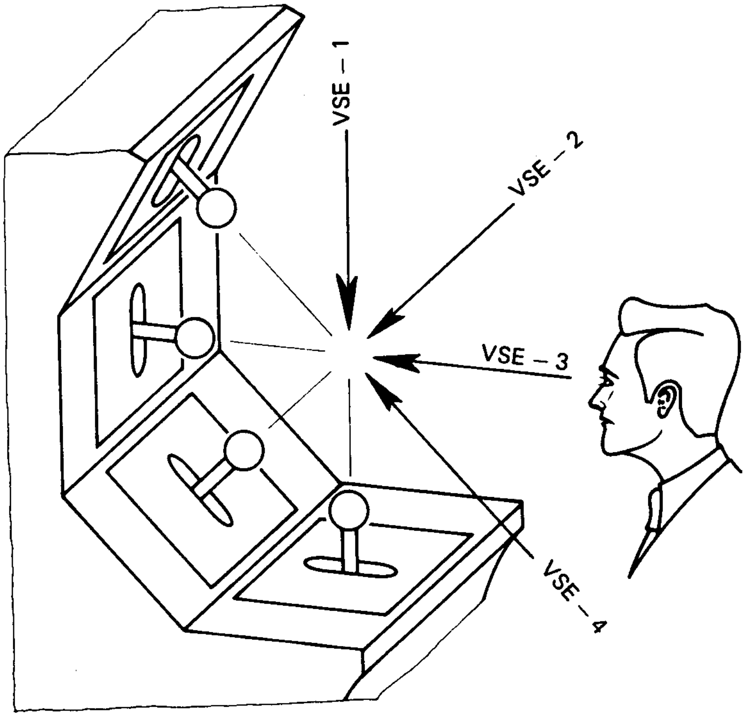


FIGURE 15 – Use of four external viewing systems VSE – 1, VSE – 2, VSE – 3 and VSE – 4 positioned at angles to each other for four switches built into a switchboard in different positions

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*See National Foreword

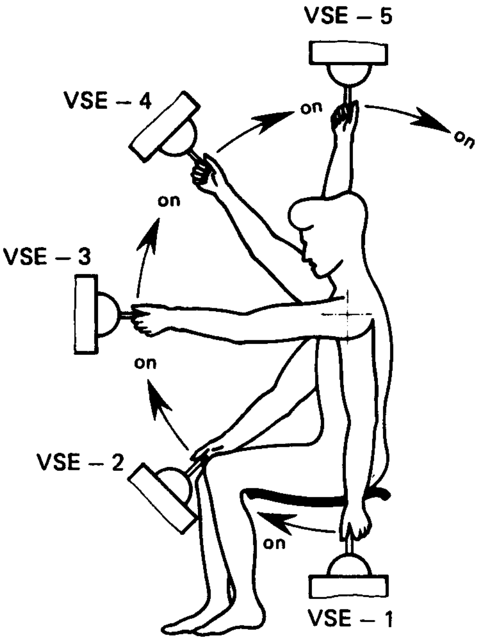

FIGURE 16 – **Operator of five switches (five different external viewing systems)**

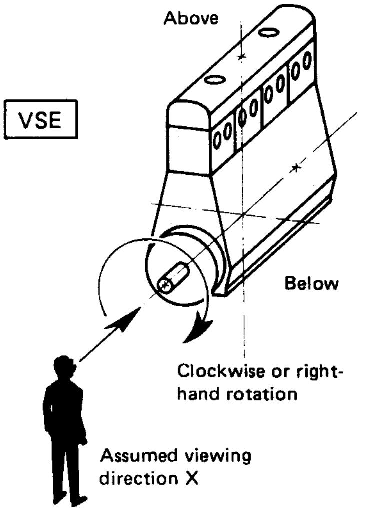

FIGURE 17 – **Determination of the direction of rotation in an internal combustion engine turning to the right according to the *external* viewing system (VSE)**

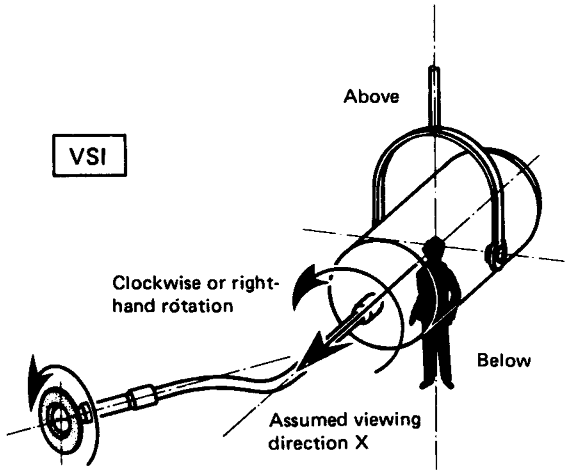

FIGURE 18 – **Determination of the direction of rotation in an electric motor with flexible shaft and tool turning to the right according to the *internal* viewing system (VSI)**

5 POSITION IN RELATION TO AN OBJECT (THREE-DIMENSIONAL ORIENTATION)

The following definitions are intended for all points at some distance from the object and not for points inside the object itself.

5.1 Pair of concepts in front – behind

In front

in the external viewing system : Position of all points which lie outwards from the transverse plane P_{yz} contrary to the viewing direction X (see figure 19).

in the internal viewing system : Position of all points which lie outwards from the transverse plane P_{yz} in the viewing direction X (see figure 20).

Behind

in the external viewing system : Position of all points which lie outwards from the transverse plane P_{yz} in the viewing direction X (see figure 19).

in the internal viewing system : Position of all points which lie outwards from the transverse plane P_{yz} contrary to the viewing direction X (see figure 20).

The directional data in front and behind are opposite each other in the two systems.

Example :

- auditorium and stage in a theatre (see figure 21).

NOTE – Whenever possible, in place of the direction indications "in front" and "behind", in the various languages, indications and descriptions should be used from which there is no doubt as to which viewing system is being used, so that any confusion is removed.

Examples :

For the internal viewing system :

- in the bow, in the stern;
- at the nose, at the tail.

For the external viewing system :

- on the side turned to the observer;
- on the side turned from the observer.

5.2 Pair of concepts right – left

Right

Position of all points which lie to the right of the longitudinal plane P_{xz}, i.e. starting from the longitudinal plane P_{xz} in the viewing direction Y along the transverse axis Y (see figures 22 and 23).

Left

Position of all points which lie to the left of the longitudinal plane P_{xz}, i.e. outwards from the longitudinal plane P_{xz} contrary to the viewing direction Y (see figures 22 and 23).

The definitions of right and left are valid both for the external viewing system (VSE) and for the internal viewing system (VSI).

Example :

- theatre with auditorium and stage (see figure 24).

  The internal viewing system (VSI) applies to the auditorium, and the external viewing system (VSE) applies to the stage.

5.3 Pair of concepts up – down/above – below

Up/above

Position of all points which lie above the basic plane P_{xy}, i.e. starting from the basic plane P_{xy} contrary to the viewing direction Z (see figures 25 and 26).

Down/below

Position of all points which lie below the basic plane P_{xy}, i.e. starting from the basic plane P_{xy} in the viewing direction Z (see figures 25 and 26).

The definitions of up and down apply both to the external viewing system (VSE) and to the internal viewing system (VSI).

Example :

- auditorium and stage in a theatre (see figure 27).

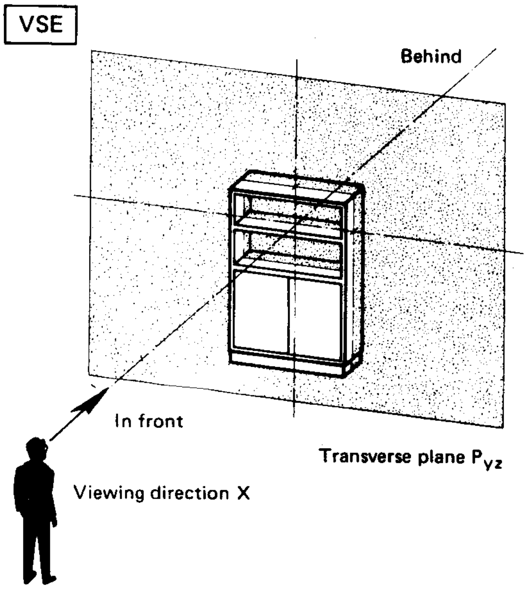

FIGURE 19 — **In front — behind; example of** ***external*** **viewing system (VSE)**

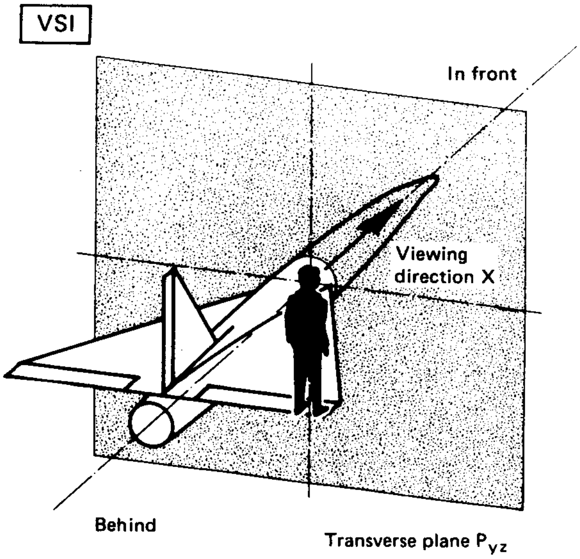

FIGURE 20 — **In front — behind; example of** ***internal*** **viewing system (VSI)**

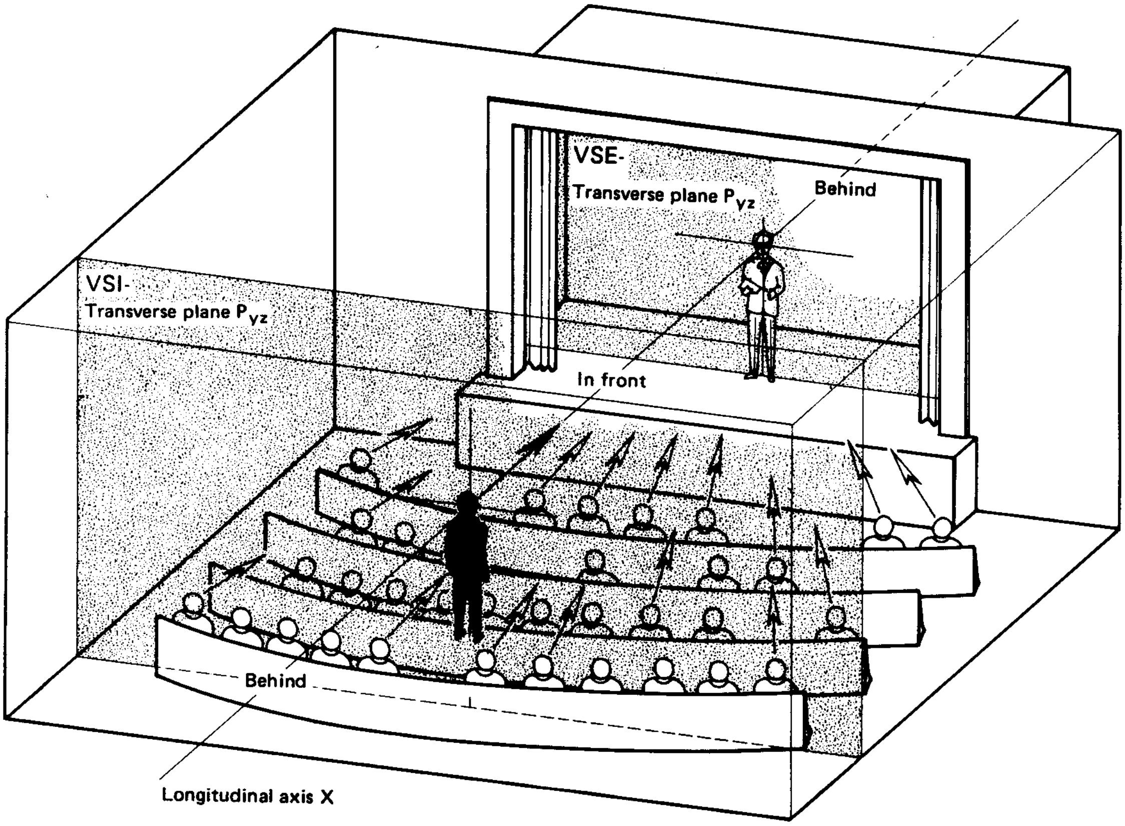

FIGURE 21 — **In front — behind, in a theatre with stage and auditorium. Differences in the external viewing system (VSE) for the stage and in the internal viewing system (VSI) for the auditorium**

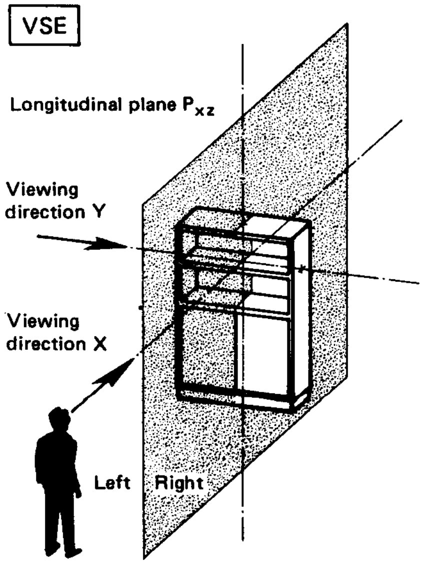

FIGURE 22 — **Right — left; example of the *external* viewing system (VSE)**

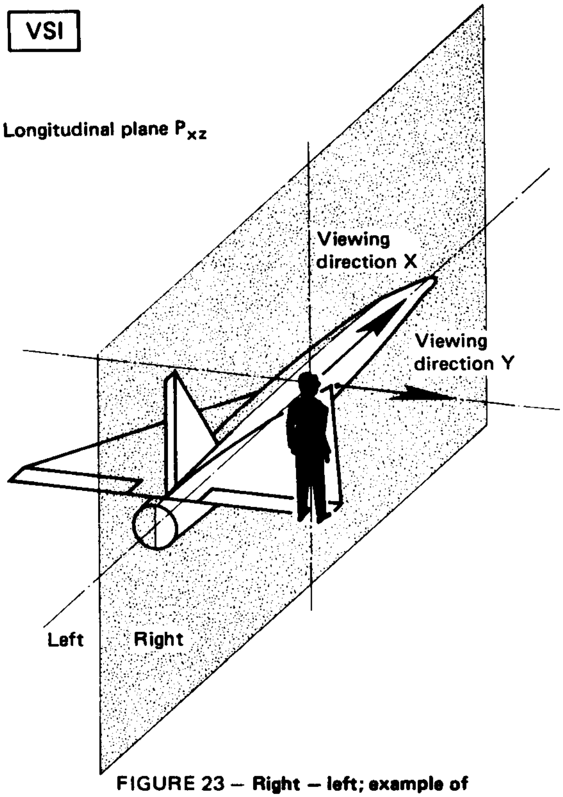

FIGURE 23 — **Right — left; example of the *internal* viewing system (VSI)**

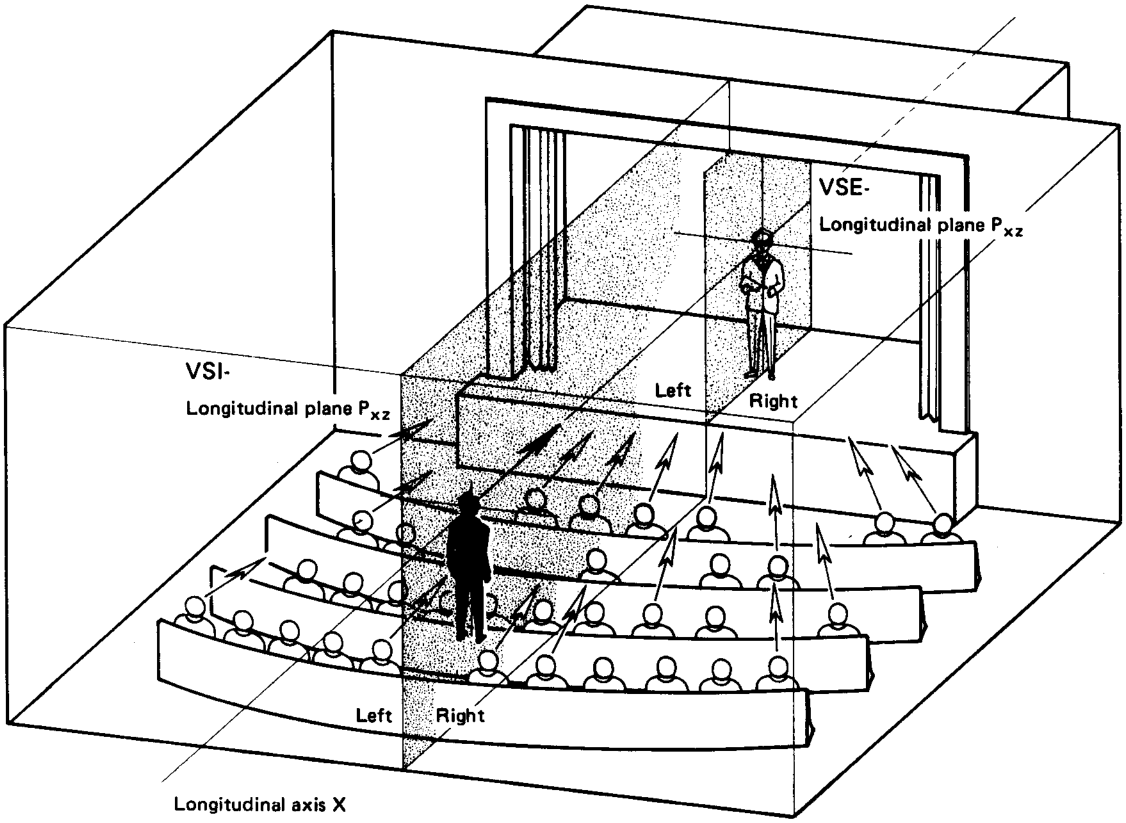

FIGURE 24 — **Right — left; in a theatre with stage and auditorium. External viewing system (VSE) for the stage, and internal viewing system (VSI) for the auditorium**

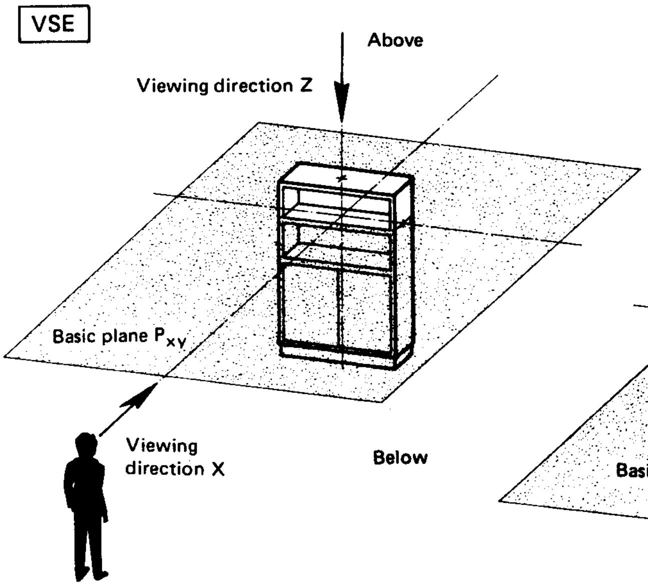

FIGURE 25 – **Above – below; example of** ***external*** **viewing system (VSE)**

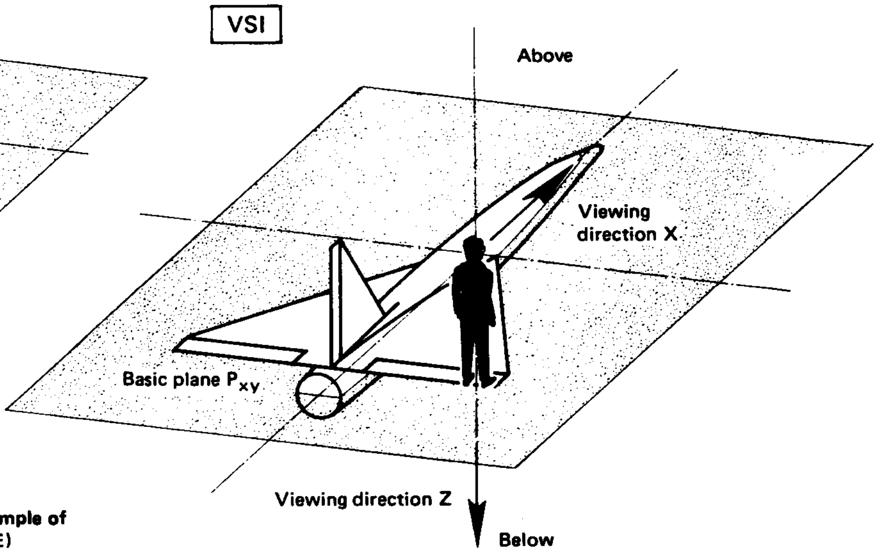

FIGURE 26 – **Above – below; example of** ***internal*** **viewing system (VSI)**

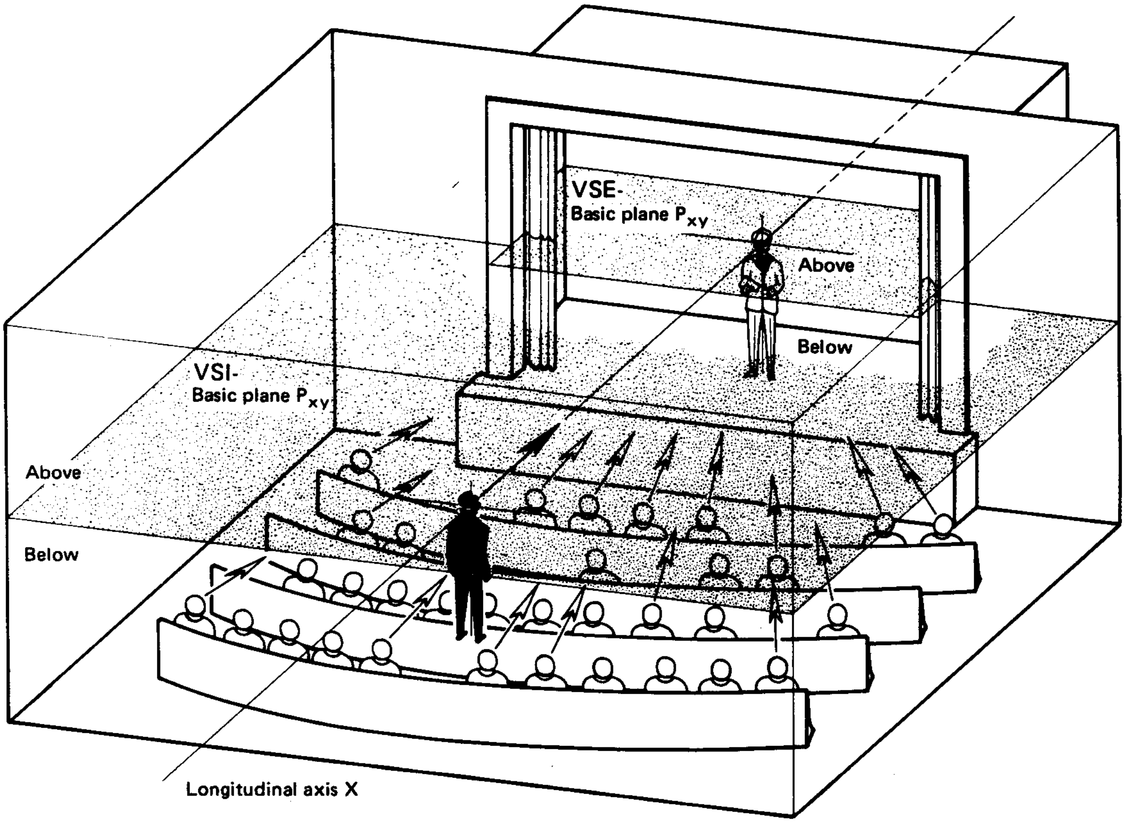

FIGURE 27 – **Above – below; in a theatre with stage and auditorium. External viewing system (VSE) for the stage, and internal viewing system (VSI) for the auditorium**

6 DIRECTIONAL CONCEPTS FOR LINEAR MOVEMENTS

6.1 Pair of concepts forwards – backwards

Movement forwards

in the external viewing system : Any movement parallel to the longitudinal axis X contrary to the viewing direction X (see figure 28).

in the internal viewing system : Any movement parallel to the longitudinal axis X in the viewing direction X (see figure 29).

Movement backwards

in the external viewing system : Any movement parallel to the longitudinal axis X in the viewing direction X (see figure 28).

in the internal viewing system : Any movement parallel to the longitudinal axis X contrary to the viewing direction X (see figure 29).

NOTE – Though in both systems the direction of movement forwards is from "behind the object" to "in front of the object" for the observer the directions of movement forwards and backwards are opposite in the two reference systems (see figures 28 and 29).

The fact that in the two reference systems the forward and backward movements are opposite may lead to confusion and, for example, in the incorrect operation of a control element may constitute a danger to persons and things.

With objects which by their very nature have their own directional system (see 2.1.1, geometrically completely orientated object) the danger of confusion is small.

In the case of objects for which the directional system is only established by convention (see 2.1.2, geometrically incompletely orientated objects, and 2.1.3, geometrically unorientated objects), the risk of confusion can be considerably reduced if the proper viewing system is established in international standards.

6.2 Pair of concepts to the right – to the left

Movement to the right

Any movement parallel to the transverse axis Y in the viewing direction Y (see figure 30).

Movement to the left

Any movement parallel to the transverse axis Y contrary to the viewing direction Y (see figure 30).

6.3 Pair of concepts upwards – downwards

Upwards movement

Any movement parallel to the normal axis Z contrary to the viewing direction Z (see figure 31).

Downwards movement

Any movement parallel to the normal axis Z in the viewing direction Z (see figure 31).

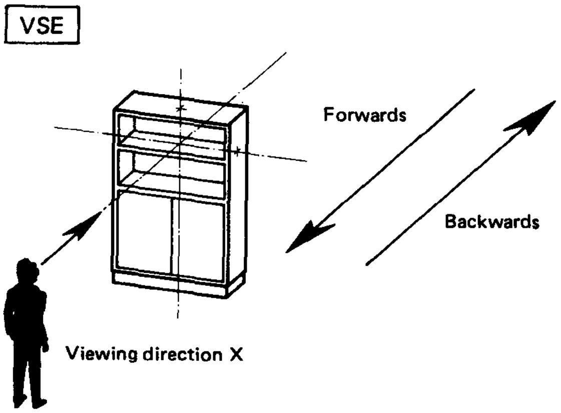

FIGURE 28 – **Directions of movements forwards – backwards; example of *external* viewing system (VSE)**

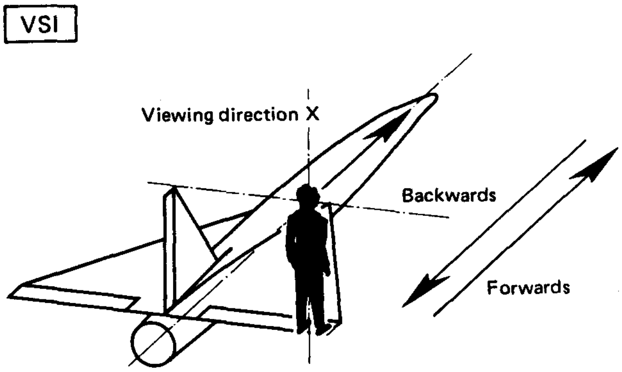

FIGURE 29 – **Directions ot movements forwards – backwards; example of *internal* viewing system (VSI)**

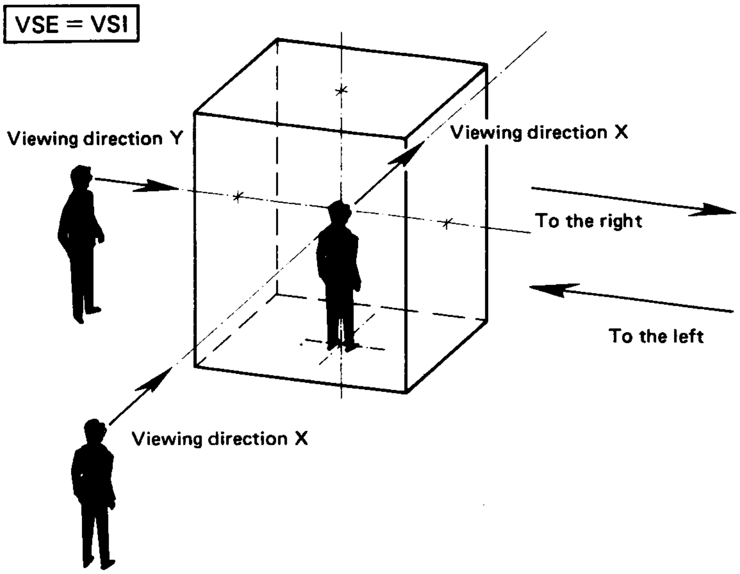

FIGURE 30 – **Directions of movements to the right – to the left, identical in the external viewing system (VSE) and in the internal viewing system (VSI)**

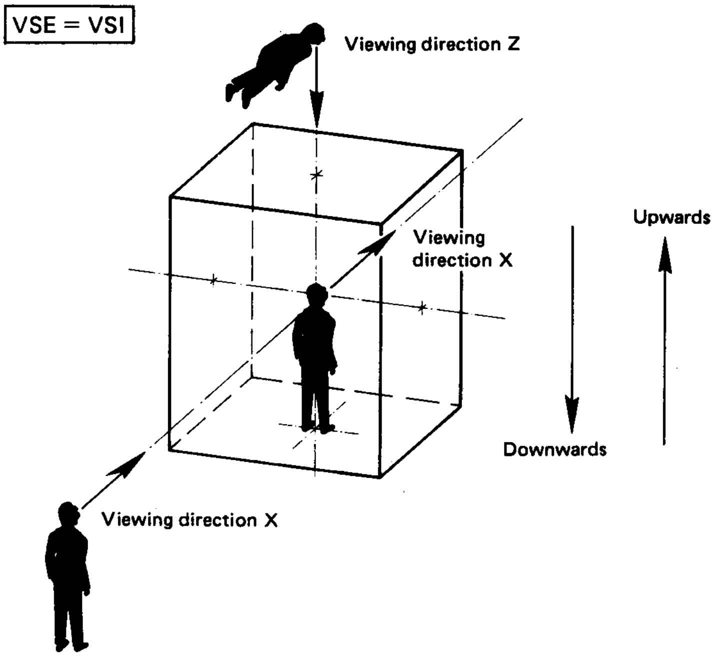

FIGURE 31 – **Directions of movements upwards – downwards, identical in the external viewing system (VSE) and in the internal viewing system (VSI)**

7 DIRECTIONAL CONCEPTS FOR ROTARY MOVEMENTS

In determining all rotary movements it is assumed that the imaginary viewing direction of the observer, irrespective of his actual location and viewing direction, coincides with the axis about which the considered object or its parts rotate.

Generally the clockwise rotary movements are positive.

NOTE — In the following sub-clauses, only rotary movements about the three mutually perpendicular axes X, Y and Z are described. In the case of rotary movements about differently positioned axes, an adequate procedure is required.

7.1 Rotations about the longitudinal axis X

Right-hand rotation about the longitudinal axis X

Rotation in which, for the observer looking in the direction X, the part of the considered object lying in front of him is turning clockwise (see figures 32 and 33).

Left-hand rotation about the longitudinal axis X

Rotation in which, for the observer looking in the direction X, the part of the considered object lying in front of him is turning anti-clockwise (see figures 32 and 33).

If the considered object is assigned to the external viewing system (VSE) the observer looks from outside in the direction X at the front side of the considered object (see figure 32).

If the considered object is assigned to the internal viewing system (VSI) the observer looks out from the centre point of the considered object in the direction X, from inside towards the front part of the considered object (see figure 33).

In both cases in a right-hand rotation the upper part of the considered object lying in front of the observer moves to the right, and in a left-hand rotation to the left (VSE = VSI).

7.2 Rotations about the transverse axis Y

Right-hand rotation about the transverse axis Y

Rotation in which, for the observer looking in the direction Y, the part of the considered object lying in front of him turns clockwise (see figures 34, 35 and 36).

Left-hand rotation about the transverse axis Y

Rotation in which, for the observer looking in the direction Y, the part of the considered object lying in front of him turns anti-clockwise (see figures 34, 35 and 36).

If the considered object is assigned to the external viewing system (VSE) the observer is looking in the direction Y from outside at the left-hand side of the considered object (see figures 34 and 35).

If the considered object is assigned to the internal viewing system (VSI) the observer is looking from the centre point in the direction Y at the inner right side of the considered object (see figure 36).

In some cases, in rotations about the transverse axis Y, for example when opening a lid (see figure 37) or when turning a cylinder which is covered to a large extent (see figure 38), the position of the observer is assumed to be in front of the considered object. As, on this supposition, no definite determination of the rotation is possible, in such cases the rotation should be paraphrased in conformity with linear movements.

Examples :

- "Opening of a lid" (see figure 37).
- "Moving the front side of the cylinder upwards (downwards)" (see figure 38).

7.3 Rotations about the normal axis Z

Right-hand rotation about the normal axis Z

Rotation in which, for the observer looking in the direction Z, the part of the considered object lying underneath him turns clockwise (see figures 39, 40 and 41).

Left-hand rotation about the normal axis Z

Rotation in which, for the observer looking in the direction Z, the part of the considered object lying underneath him moves anti-clockwise (see figures 39, 40 and 41).

If the considered object is assigned to the external viewing system (VSE) the observer is looking from outside in the direction Z at the top side of the considered object (see figures 39 and 40).

If the considered object is assigned to the internal viewing system (VSI) the observer is looking from the centre in the direction Z from the inside at the lower part of the considered object (see figure 41).

NOTE — An unambiguous determination of the rotation about the normal axis Z is only possible if position, posture and viewing direction of the observer, irrespective of the actual situation, are assumed to be determined in a definite way. This has been realized in figures 39 and 40 by the external viewing system, and in figure 41 by the internal viewing system.

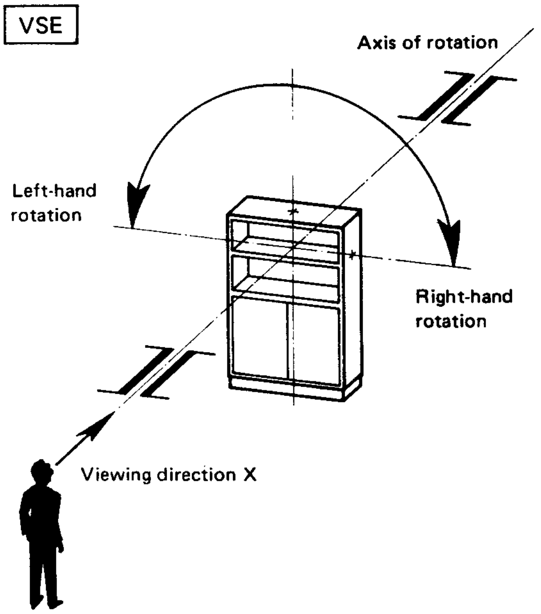

FIGURE 32 – **Right-hand rotation (*clockwise*) and left-hand rotation (*anti*-clockwise) about the longitudinal axis X; example of external viewing system (VSE)**

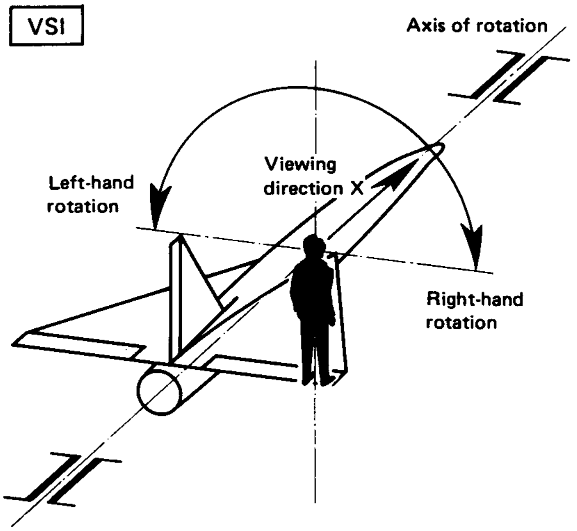

FIGURE 33 – **Right-hand rotation (*clockwise*) and left-hand rotation (*anti*-clockwise) about the longitudinal axis X; example of internal viewing system (VSI)**

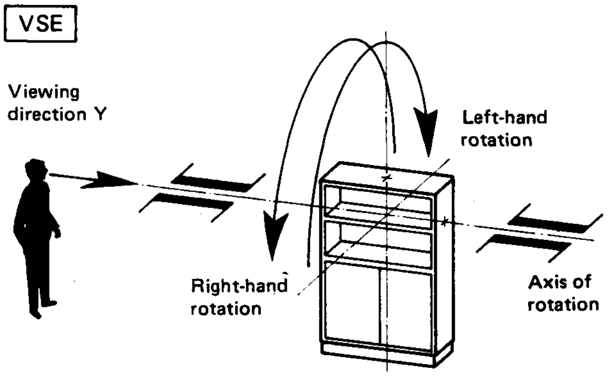

FIGURE 34 – **Right-hand rotation (*clockwise*) and left-hand rotation (*anti*-clockwise) about the transverse axis Y; example of external viewing system (VSE)**

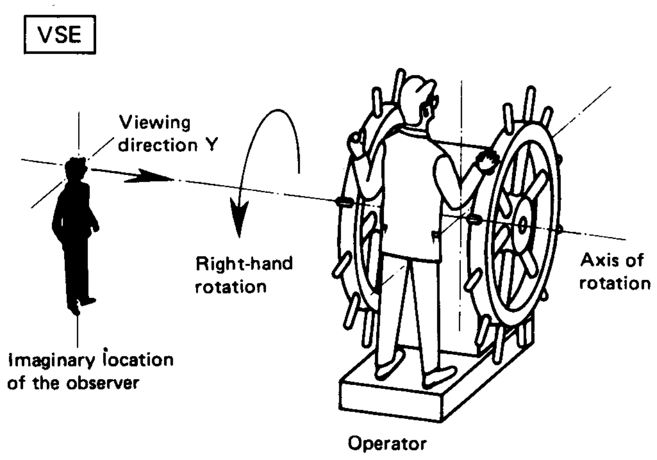

FIGURE 35 – **Determination of the rotation of a shaft transverse axis Y with two steering wheels, by means of the external viewing system**

NOTE – As is shown in figure 35, an unequivocal determination of the rotations about the transverse axis Y is only possible if position, posture and viewing direction of the observer, irrespective of the actual situation, are assumed to be determined in a definite way. This has been realized in figure 35 by the external viewing system. Without this convention, one and the same rotation of the shaft by means of the two hand-wheels could either be taken as a right-hand movement or as a left-hand movement, depending on whether the observer is looking from the left to the right (as supposed here) or from the right to the left.

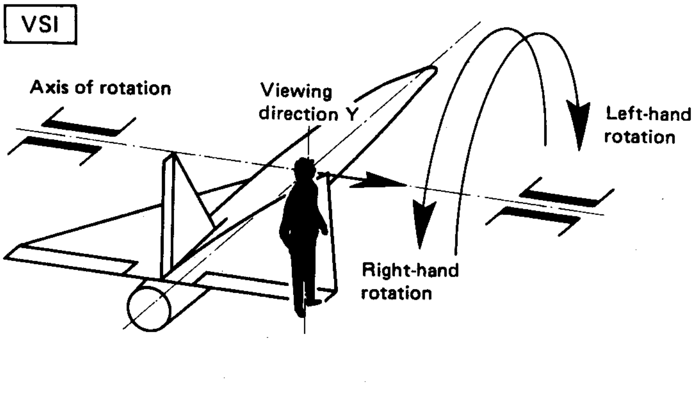

FIGURE 36 – **Right-hand rotation (*clockwise*) and left-hand rotation (*anti*-clockwise) about the transverse axis Y, example of internal viewing system (VSI)**

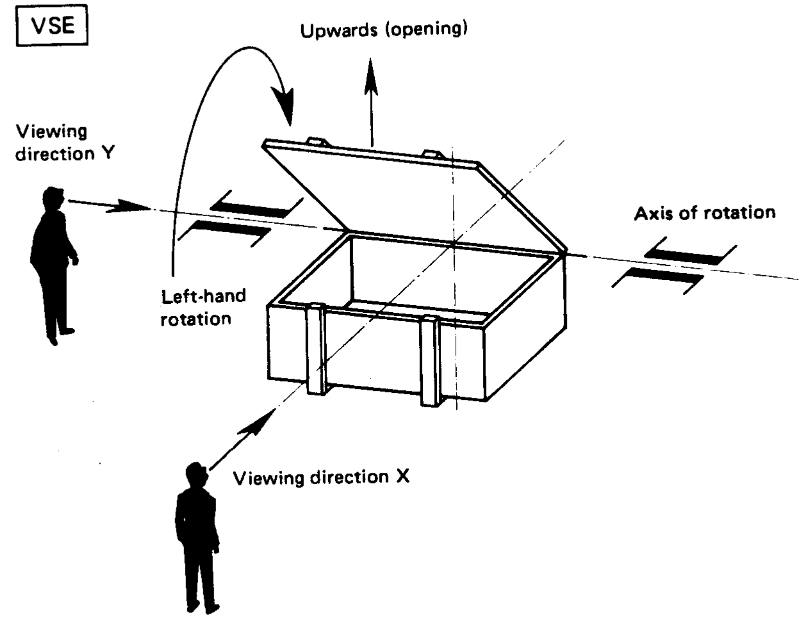

FIGURE 37 – **Left-hand rotation about the transverse axis Y, described as linear movement of the lid of the box upwards**

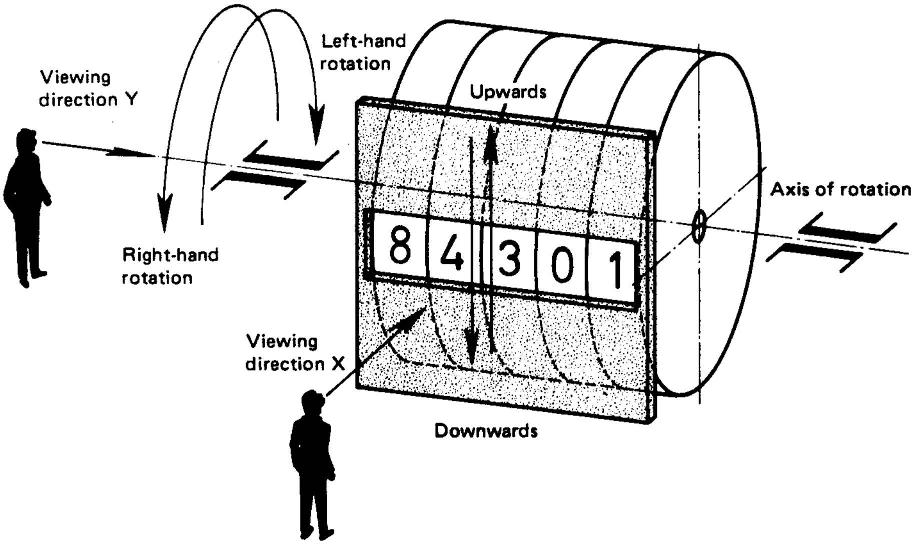

FIGURE 38 – **Transcription of a rotation by a linear movement (upwards or downwards). Example : Counter**

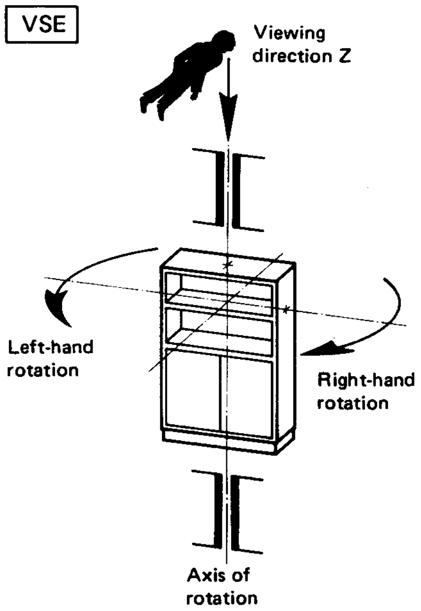

FIGURE 39 – **Right-hand rotation (*clockwise*) and left-hand rotation (*anti*-clockwise) about the normal axis Z; example of external viewing system (VSE)**

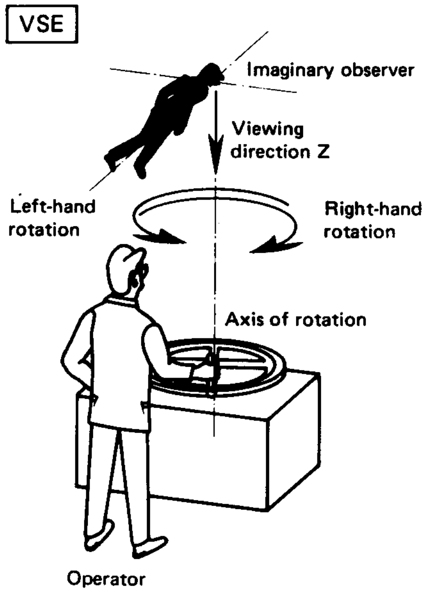

FIGURE 40 – **Right-hand rotation (*clockwise*) and left-hand rotation (*anti*-cloclwise) about the normal axis Z; example of external viewing system (VSE)**

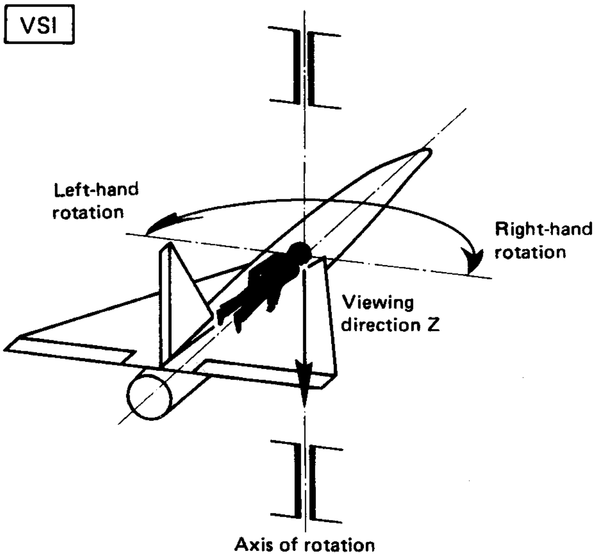

FIGURE 41 – **Right-hand rotation (*clockwise*) and left-hand rotation (*anti*-clockwise) about the normal axis Z; example of internal viewing system (VSI)**

8 COMBINED TWO-DIMENSIONAL MOVEMENTS

Movements which comprise a linear and rotary movement.

Circular movements and indeed right-hand circular movement (clockwise) and left-hand circular movement (anticlockwise), as well as movements in a right-handed curve and left-handed curve, are a special case of combined movement in one plane.

8.1 Circular movement

Movement about a centre point at certain radius.

Circular movement is a movement in the reference plane with constant change. It may be resolved into two components, for example a component of movement along the longitudinal axis X and a component of movement in the transverse axis Y.

Right-hand circular movement

Circular movement in a clockwise direction for an observer looking towards the reference plane along the rotation axis passing through the centre of the circle C (see figure 42).

Left-hand circular movement

Circular movement in an anti-clockwise direction for an observer looking towards the reference plane along the rotation axis passing through the centre of the circle C (see figure 42).

The viewing directions assumed for the definitions of the circular movement are parallel to the viewing directions which have been assumed for the definitions of the corresponding circular movements about the longitudinal axis X, the transverse axis Y, and the normal axis Z (see 7.1 to 7.3).

8.2 Movement along a level curve

Movement along a plane with continual alteration of the direction of movement.

Movement along a level curve can also be taken as a movement resulting from two linear movements, which are rectangular to each other, i.e. by combining a forwards or backwards movement with a movement to the left or to the right (see definitions in 6.1 and 6.2).

The definition of movement in a level curve is significant only in the internal viewing system (VSI).

Movement along a right-hand curve

In a forward movement : Movement resulting from a linear movement forward in the direction of the longitudinal axis X (in the viewing direction X) and a linear movement to the right in the direction of the transverse axis Y (in the viewing direction Y).

In a backward movement : Movement resulting from a linear movement in the direction of the longitudinal axis X backwards (contrary to the viewing direction X) and a linear movement in the direction of the transverse axis Y to the right (in the viewing direction Y) (see figure 43).

Movement along a left-hand curve

In a forward movement : Movement resulting from a linear movement in the direction of the longitudinal axis X forwards (in the viewing direction X) and a linear movement in the direction of the transverse axis Y to the left (contrary to the viewing direction Y).

In a backward movement : Movement resulting from a linear movement in the direction of the longitudinal axis X backwards (contrary to the viewing direction X) and a linear movement in the direction of the transverse axis Y to the left (contrary to the viewing direction Y) (see figure 44).

Vehicles in which the front and the back are not unambiguously established, are geometrically speaking incompletely orientated objects (see 2.1.2). In this case unambiguous directional indications are only possible if the viewing system is established by convention. Only the internal viewing system (VSI) is meaningful.

To avoid misunderstandings in any case it is sometimes suitable to use directional indications, from which the relationship to the vehicle appears unambiguously, for example :

- right-handed curve : backwards – to starboard;
- left-handed curve : backwards – to port.

8.3 Other combined two-dimensional movements

For the unambiguous determination of other combined two-dimensional movements, first of all the viewing system, i.e. the location, position and viewing direction of the observer, must be established as in the case of simple linear movements and rotary movements.

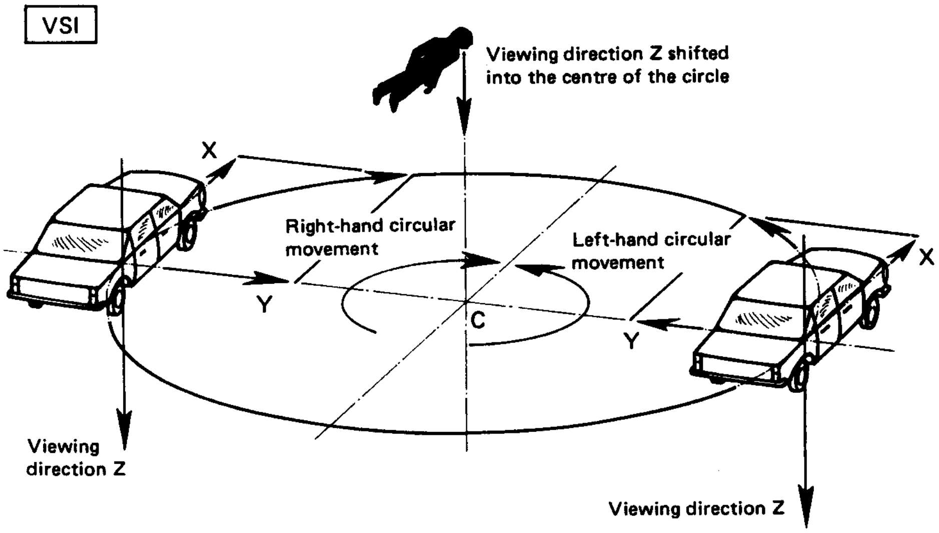
VSI
Viewing direction Z shifted into the centre of the circle
X
Right-hand circular movement
Left-hand circular movement
X
Y
C
Y
Viewing direction Z
Viewing direction Z

FIGURE 42 – **Right-hand circular movement (*clockwise*) and left-hand circular movement (*anti*-clockwise) about the normal axis Z**

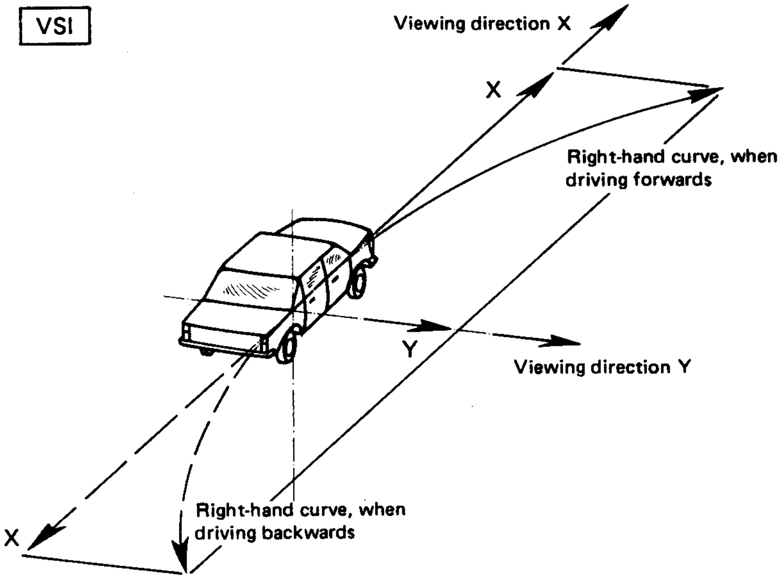
VSI
Viewing direction X
X
Right-hand curve, when driving forwards
Y
Viewing direction Y
X
Right-hand curve, when driving backwards

FIGURE 43 – **Right-hand curve**

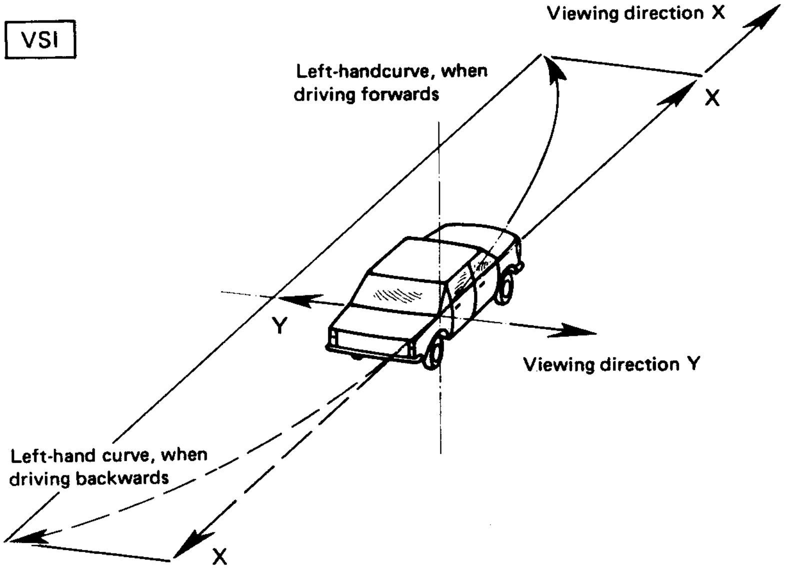
VSI
Viewing direction X
Left-handcurve, when driving forwards
X
Y
Viewing direction Y
Left-hand curve, when driving backwards
X

FIGURE 44 – **Left-hand curve**

9 THREE-DIMENSIONAL MOVEMENTS

Simultaneous movement in several planes.

Three-dimensional movements may be determined by single movements in different planes. Screw motion is a special case of three-dimensional movement.

9.1 Screw motion

Movement which is composed of a rotary movement about a determined axis and a simultaneous and corresponding linear movement along this axis.

Screw movements, irrespective of the real location, position, and viewing direction of the observer, are always unambiguous, because they are defined only according to the internal viewing system (VSI). Therefore they are especially suitable definitions in which directions and movements play a role.

Right-handed screw motion

Linear movement in the viewing direction of the observer, combined with a simultaneous rotation to the right (clockwise rotation) (see figures 45, 47 and 49).

Left-hand screw motion

Linear movement in the viewing direction of the observer, combined with a simultaneous rotation to the left (anticlockwise rotation) (see figures 46, 48 and 50).

9.2 Other three-dimensional movements

Three-dimensional movements play a special role in gear technology, ballistics, and sea, air and space navigation.

The following concepts[1] used in stabilization technology and air and sea navigation for three-dimensional movements may, with the help of the internal viewing system (VSI), be defined as follows :

9.2.1 Roll

Simultaneous (generally periodic oscillating) movement of the craft about the longitudinal axis X (right- and left-hand rotation about the longitudinal axis X) combined with a linear basic movement in the direction of the longitudinal axis X forwards (in the viewing direction X) or possibly, backwards.

9.2.2 Pitch

Simultaneous (generally periodic oscillating) movement of the craft about the transverse axis Y (right- and left-hand rotation about the transverse axis Y = movement up and down of bow and stern or nose and tail) combined with a linear basic movement in the direction of the longitudinal axis X forwards (in the viewing direction X) or possibly, backwards.

9.2.3 Yaw

Simultaneous (generally periodic oscillating) movement of the craft about the normal axis Z (right- and left-hand rotation about the normal axis Z = periodic deviation of the course) combined with a linear basic movement in the direction of the longitudinal axis X forwards (in the viewing direction X) or possibly, backwards.

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[1] Further three-dimensional movements cannot be dealt with here, because this International Standard deals only with principles and not individual cases in given subjects.

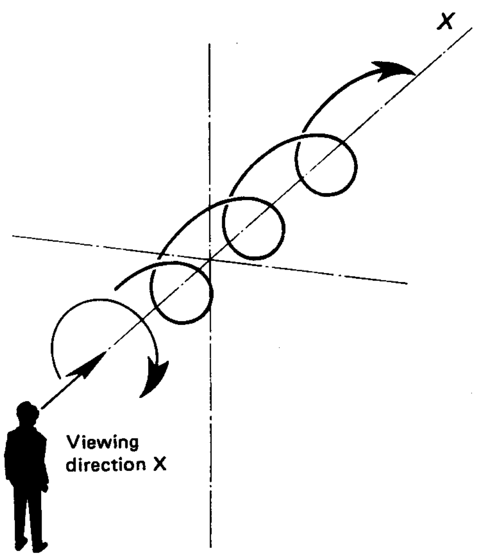


FIGURE 45 – **Right-hand screw movement about and along the longitudinal axis X**

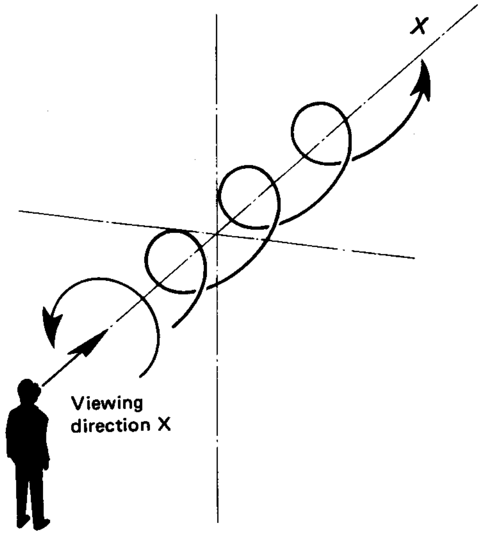


FIGURE 46 – **Left-hand screw movement about and along the longitudinal axis X**

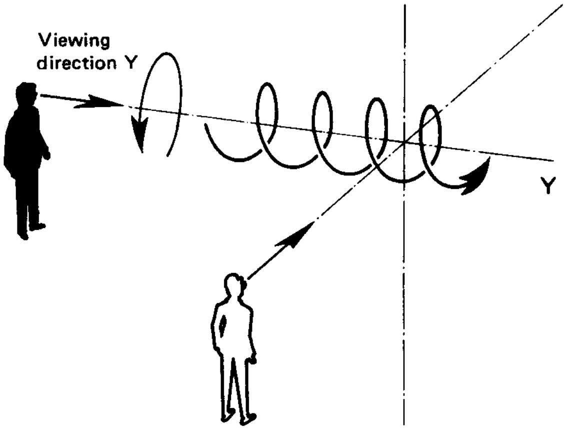


FIGURE 47 – **Right-hand screw movement about and along the transverse axis Y**

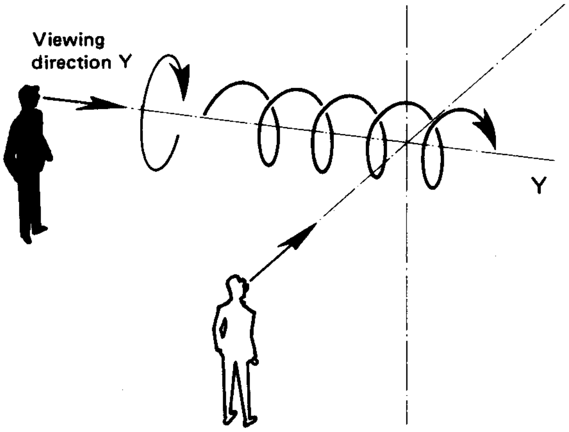


FIGURE 48 – **Left-hand screw movement about and along the transverse axis Y**

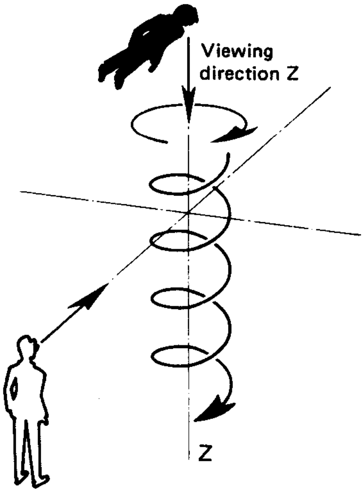


FIGURE 49 – **Right-hand screw movement about and along the normal axis Z**

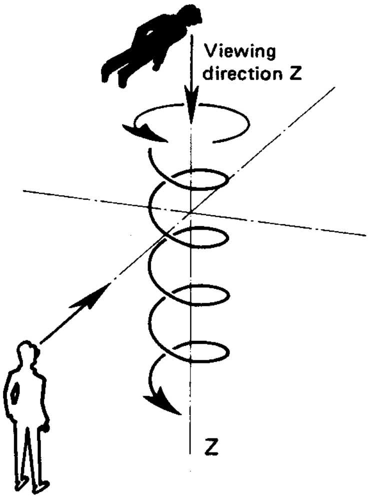


FIGURE 50 – **Left-hand screw movement about and along the normal axis Z**

10 DIRECTIONS OF MOVEMENT IN CONTROL ELEMENTS

10.1 Control element

Mechanical, electrical, pneumatic, hydraulic or other component which can be controlled by physical or even chemical processes for the control of movements and other changes in the considered object.

10.2 Co-ordination of the directions of movement in control elements to intended movements of the considered object

In connection with this International Standard, the only control elements of interest are those by means of which, via the operator, linear movements, rotary movements, or combined two-dimensional or three-dimensional movements are produced in order to achieve a definite effect.

It is to be observed that most people give preference in the pairs of concepts used for the determination of movements at any one time to one concept. This wide-spread habit may be used for safety in control procedures (see table, page 30).

Movements in control elements and the intended changes in the considered object should be logically co-ordinated. A linear movement to the right should, for example, be logically obtained by pushing a lever to the right. A rotary movement to the right should, for example, be obtained by turning a hand-wheel to the right. If a lever cannot be used, the linear movement to the right should be produced by turning a hand-wheel to the right or operating the right-hand one of two corresponding push buttons (see table, page 30).

10.3 Co-ordination of the directions of movement in the control element to intended other effects in the considered object

The fact that in the case of pairs of concepts one concept is preferred at any one time is valid not only for directional concepts but also for intended changes of any kind in the considered object (see table, page 30).

Like the claim in 10.2, it is logical to co-ordinate at any one time the preferred movement in the control element with the preferred change in the observed object.

In the past, this simple rule has often been violated. This may have the consequence that for example in an emergency, a person hurrying to give assistance, and who is not acquainted with the peculiarities of the given control element, instinctively initiates a wrong control action and thereby is hindered in bringing help or may even cause a disaster.

It is, however, even more dangerous to change the customary directions of movement in control elements. When, therefore, control elements are to be harmonized, the direction of the existing control element should never be changed but instead the control element itself should be replaced by a completely different kind of control element, for example replacement of a hand-wheel by a lever or push-button switch.

Thus, logically there follow the principles drawn up in 10.4, for the assimilation of movements of control elements.

10.4 Principles for the harmonization of directions of movement of control elements to the rules of this International Standard

10.4.1 *First principle*

Like movements and like changes in like, similar and also different objects should as far as possible be controlled by the operation of similar control elements in the same direction of movement. In this way the need for operating personnel to relearn when changing their place of work is avoided. It is also accepted as very probable that the operating elements will be controlled instinctively in the right way by unfamiliar operating personnel in an emergency.

10.4.2 *Second principle*

When, for any technical reasons, like movements or like changes in different objects must be effected with different control elements, the movement of the control element and the change in the considered object should at least correspond to the series of pairs of concepts in the table on page 30 (see also annex A).

10.4.3 *Third principle*

The control movement associated with an intended effect must never be reversed. The adaptation of the steering movement to meet the first or second principles should only be achieved by changing the entire control element.

Examples :

1) If the rotation of a hand-wheel to the right has hitherto resulted in the movement of a machine part to the left, the right-hand rotation should not in future cause a movement of the machine part to the right. However, the hand-wheel may be replaced by a lever or push-buttons, whose control movement corresponds to the requirements in 10.4.1 or 10.4.2.

2) If the raising of a lever in a motor vehicle has hitherto caused the left flashing indicator to light up, it should not in future cause the right indicator to light up. However, the lever may, for example, be set at right angles or be replaced by push-buttons or a rotating control element.

10.4.4 *Fourth principle*

In any adaptation of the directions of movement of control elements to the first or second principles, in each case unambiguous additional symbols or a corresponding inscription should be introduced. Meaningful symbols are preferable to an inscription in this case, since they can be more easily understood internationally.

However, unambiguous symbols should as far as possible be mounted also on the control elements, if these have not been converted to the principles in 10.4.1 or 10.4.2. Safety will in any case be increased in this way. The symbols and the meaning of the directions of movement in the control elements, therefore, are instilled effectively by repetition and enter into the subconscious memory of the operators, thereby increasing the probability that any emergency will be correctly dealt with.

TABLE – **Pairs of terms for the co-ordination of control elements to any changes on the considered object**
(see also annex A)

	Group 1	**Group 2**
Position	right, starboard above up top in front VSE : on the side turned to the observer VSI : in the bow; at the nose beginning	left, port below down bottom behind VSE : on the side turned from the observer VSI : in the stern; at the end end
Direction of movement	to the right upwards, upward away from the operator clockwise rotation	to the left downwards, downward towards the operator anti-clockwise rotation
	(In this table the directions of movement forwards and backwards are not included because these terms have a different meaning in the two viewing systems VSE and VSI.)	
Condition	light warm loud fast plus (+) accelerate to increase effects, for example : brightness speed power pressure temperature voltage current frequency luminous intensity	dark cold soft, quiet slow minus (–) decelerate (brake) to reduce effects, for example : brightness speed power pressure temperature voltage current frequency luminous intensity
Action	to switch on to put into service to start, to go to fasten, to engage to close a valve to close an electric circuit to ignite to fill to push, to depress	to switch off to put out of service to stop to release to open a valve to open an electric circuit to extinguish to empty to pull

ANNEX A

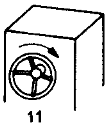
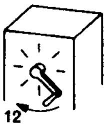
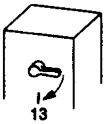
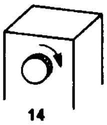
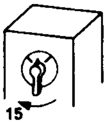
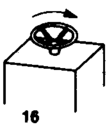
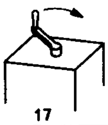
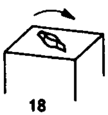
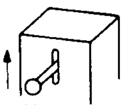
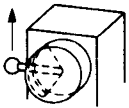
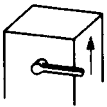
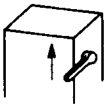
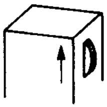
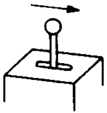
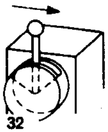
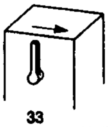
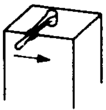
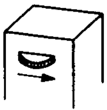
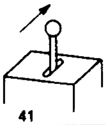
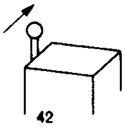
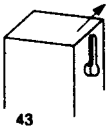
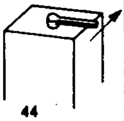
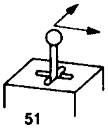
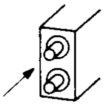
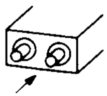
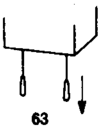
EXTRACT FROM IEC PUBLICATION 447

(for information)

Examples of directions of movement for some types of actuators

In every figure the arrow is related to the Group 1 action.

The operator is considered to be in the place of the figure numbers.

Rotation		 11	 12	 13	 14	 15	 16	 17	 18
Vertical motion		 21	 22	 23	 24	 25			
Horizontal motion	Right – left	 31	 32	 33	 34	 35			
	*Forward – backward	 41	 42	 43	 44				
Combination of different directions		 51							
Set of actuators		 61	 62	 63					

*Away from the operator
towards the operator.

ANNEX B

VOCABULARY – English

No.	English
1	Considered object
2	Geometrical orientation
3	Fully orientated object geometrically speaking
4	Incompletely orientated object geometrically speaking
5	Object not geometrically orientated
6	Centre point
7	Axis of the considered object
8	Longitudinal axis X
9	Transverse axis Y
10	Normal axis Z
11	Reference plane
12	Basic plane P_{xy}
13	Longitudinal plane P_{xz}
14	Transverse plane P_{yz}
15	Observer
16	Location of the observer
17	Posture of the observer
18	Viewing direction of the observer
19	Viewing system
20	External viewing system (VSE)
21	Internal viewing system (VSI)
22	*Three-dimensional orientation*
23	Right Left
24	Above, up Below, down
25	In front Behind
26	*Linear movements*
27	To the right To the left
28	Upwards, upward[1] Downwards, downward[1]

[1] In the U.S.A. the preferred spelling is : upward, downward.

No.	English
29	Forwards, forward[1] Backwards, backward[1]
30	Forward movement Backward movement
31	*Rotary movements*
32	Right-hand rotation Left-hand rotation
33	Clockwise rotation Anti-clockwise rotation[2] Counterclockwise rotation[2]
34	*Combined two-dimensional movements*
35	Circular movement
36	Right-hand circular movement Left-hand circular movement
37	Right-hand movement in a curve Left-hand movement in a curve
38	*Three-dimensional movements*
39	Screw motion
40	Right-hand screw motion Left-hand screw motion
41	Right-hand movement in a curve Left-hand movement in a curve
42	*Control element*

[1] In the U.S.A. the preferred spelling is : forward, backward.

[2] Instead of anti-clockwise the term counterclockwise is preferred in the U.S.A.

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